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INFLUENCE OF AGEING BEHAVIOR ON HARDNESS OF SQUEEZE CAST AL 8011 WITH 2.5%TIC COMPOSITES USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

In this work, the effect of precipitation hardening on hardness of Al 8011 reinforced with 2.5 % TiC composites have been investigated. The composites are fabricated by employing squeeze cast process; it is the combination of both casting and forging processes that can be done under high pressure. Since it results in negligible porosity, refined grain structure and high quality cast composites. The precipitation hardening process was carried out within a temperature range of 130 - 210°C for the time interval of 1-8 hours. Hardness was recorded closely to monitor the age of hardening effect and ANN is employed ascertain the optimum hardness using ANN as a tool

Key words: *Precipitation hardening, squeeze casting, Aritificial neural network*

1. Introduction

In the current industrial scenario, metal matrix composites materials fabricated with nano particles are gaining a major role to play in defense, aerospace, automobile industries, electronic packaging applications due to their high strength weight ratio, good machinability etc.In particular, Al MMC'S in these industries have wider applications due to its drastic weight reduction and exceptional properties like high wear and corrosion resistance, metallurgical and tribological properties, which require high creep resistance, good thermal conductivity, low thermal expansion co-efficient is achieved by new fabrication techniques and methods.

Here TiC reinforcement is used to fabricate an Al 8011 composites squeeze the casting the process under high pressure. Then the casted samples are subjected to precipitate and it undergoes to hardening treatment mainly to improve the hardness of the samples. Hence this work, heat treatment of Al 8011 composites was carried out to increase the hardness.

Metal matrix composite leads to the significant savings in materials and energy and reduce pollution through the use of ultra-strong materials properties [1]. The age hardening response of the composites was faster than the alloy due to the presence of particulate reinforcements that can accelerate the aging kinetics. Micro structural examination of the composites revealed uniform distribution of reinforcement in the matrix [2]. The squeeze cast pressure, die pre-heating temperature and compression holding time were the parameters makes the significant improvement in the mechanical properties of Al MM'C [3]. The optimal parametric combination i.e., solutioning time-3h, ageing temperature- 170ºC,ageing time-5hr was found out to achieve the maximum tensile strength of 265 Mpa and micro hardness of 67.17 is achieved [4]. The age hardening and annealing heat treatment operation eliminated these micro-segregations and improve the mechanical properties of Al 7075 alloy. The micro segregations can be eliminated by rapid solidification and appropriate heat treatment process [5]. The hardness of the as cast sample increased from 110 VHN to 147.2 VHN with heat treatment [6].The aged material is generally stronger than the as cast material and appropriate solution treatment temperature and holding time has decisive effects on the strengthening, hardening and ductility of alloy [7].

The mechanical properties of the composite are higher in age hardened samples than the as cast samples, most likely due to the precipitation of a second phase during ageing which cover the surface at the particles-matrix interfaces. The hardness increased with aging time [8]. The use of nano-particles gives the better results in ultimate tensile strength and hardness [9]. Hardness, density was increased with increase in TiC and TiO_2 content in Al composite material [10]. The wear rate decreases linearly with increase volume fraction of titanium carbide. Average co-efficient of friction also decreases linearly with increasing normal load and volume fraction of TiC [11].

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1.1Materials used in this study

The qualitative chemical analysis was performed using spectroscopic analysis and the chemical composition of Al 8011 is given in Table 1.

Table 1. Chemical composition of Al 8011

Ele ment	Si	Fe	Mn	Mg	Cu	Zn	Ti	Cr	Al
Al 8011	0.6	0.8	0.10	0.05	0.10	0.10	0.08	0.05	Bal

Table 2. Properties of Al 8011

Element	Density g/cm3	Melting point °C	Modulus of elasticity Gpa	Thermal conductivity W/m.k
Al 8011	2.7	660	70.3	237

Table 3. Details of reinforcements

Reinforce ments	Grain size µm	Density g/cm^3	Melting point °C	Modulus of elasticity Gpa	Thermal conductivity W/m.k
TiC	40	4.93	3250	450	28.9

TiC particles having wide commercial applications such as abrasive materials, cutting tools, grinding wheels and coated cutting tips and excellent properties were the reason for selection of reinforcement materials.

2. Experimental Work

In this study, Al 8011 is used as base matrix materials. Here TiC powder with 99% purity of metal base of average particle size of 2 micron powder is imported from Alfa Aesar from USA are purchased and used as reinforcement materials. In this work 2.5% of TiC was preheated in the furnace of 500ºC for 3 hrs to improve the wettability, bonding between the matrix and the reinforcement material. Molten metal was prepared using electrical resistance crucible furnace and the operating squeeze cast parameters were given in Table 4. The pre-heated reinforcement material were poured in to the furnace and finally the squeeze cast composite material of 50mm diameter and 220mm length were obtained for the alloys.

Table 4. Squeeze casting operating parameters

Furnace temp °C	Melt temp °C	Stirrer speed rpm	Stirrer holding time min	Squeeze pressure bar	Squeeze holding time min
800	736	600	30	35	10

Fig. 1 Squeeze Casting Setup

Sample of 50 mm diameter and 10 mm height is cut in to 40 pieces using wire EDM machine.

2.1 Precipitation hardening heat Treatment

After cleaning the as cast samples, precipitation hardening or age hardening tests were carried out in the muffle furnace with the ageing temperatures range of 130-210ºC and the ageing time of 1-8 hours, then followed by atmospheric cooling to room temperature.
Micro hardness values were recorded for both samples using Wilson hardness Vickers 402 MVD Tester at 300 kgf load with a dwell time of 10 seconds. All 40 samples were used for hardness testing in accordance with ASTM standard E18-02.

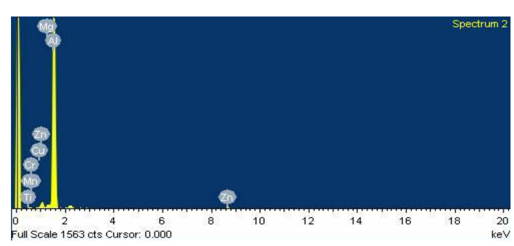

Fig. 2 EDX spectrum of Al 7075 with TiC

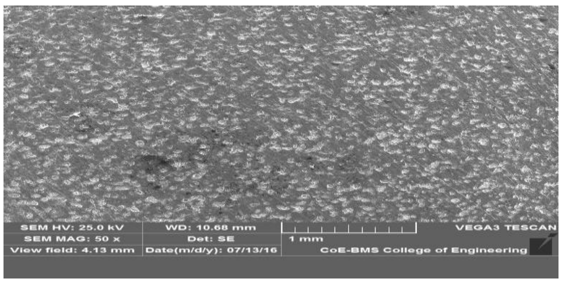

Fig. 3 SEM image showing the uniform distribution of TiC with Al 7075 matrix with 50X

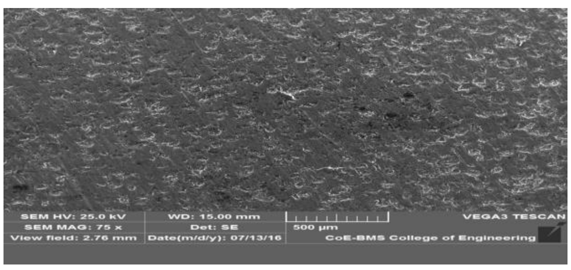

Fig. 4 SEM image showing the uniform distribution of TiC with Al 7075 matrix with 75 X

3. Mathematical Modeling Ann

To predict the optimum ageing temperature and ageing time for improving the hardness a novel mathematical model is developed using ANN. Several ANN topologies have been developed for different applications, the most popular being the “feed forward back propagation network”. It is a gradient descent error-correcting algorithm, which updates the weights in such a way that the network output error is minimized. A multilayer contains one or more layers between the input and output layers and those layers are called as hidden layers. The back propagation algorithm performs two phases of data. First the ageing temperature and ageing time as the input and the micro hardness as the output is given. Once the network was sufficiently “trained”, a general model was created for the relationship between inputs and outputs.

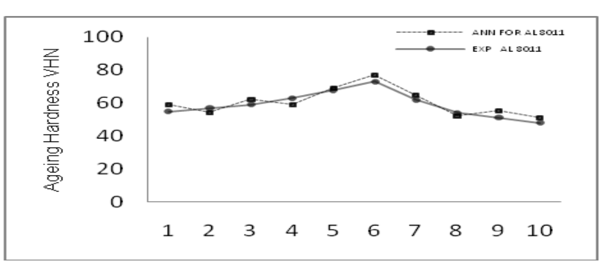

Fig. 5 Graph showing the experimental results predicted by ANN for Al 8011

4. Results and Discussion

It is evident that at higher temperatures, the movement of solute is faster and ageing take place faster at higher temperature but equilibrium and stability at high temperatures of solute is affected and hence it may lead to lower hardness [8]. Figure [8-12] shows the highest and lowest hardness values of composites of Al 8011 alloy obtained respectively.

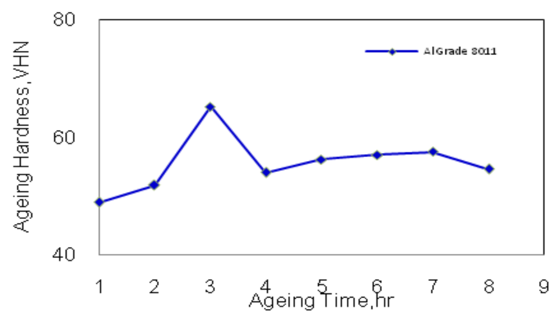

Fig. 6 Effect of ageing temperature at 130º C on Hardness of Al 8011

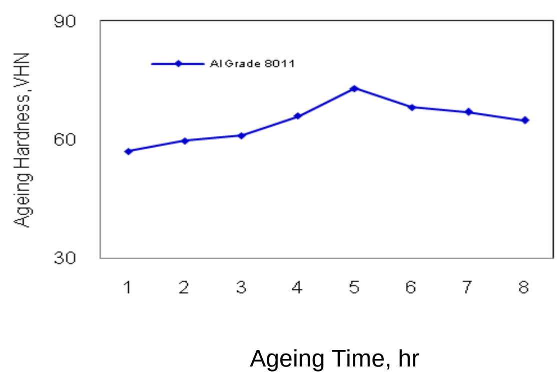

Fig. 7 Effect of ageing temperature at 150º C on Hardness of Al 8011

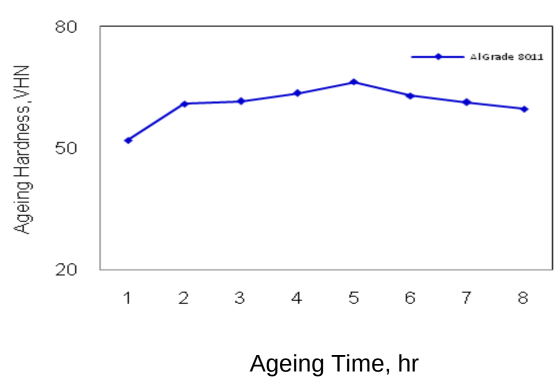

Fig. 8 Effect of ageing temperature at 170º C on Hardness of Al 8011

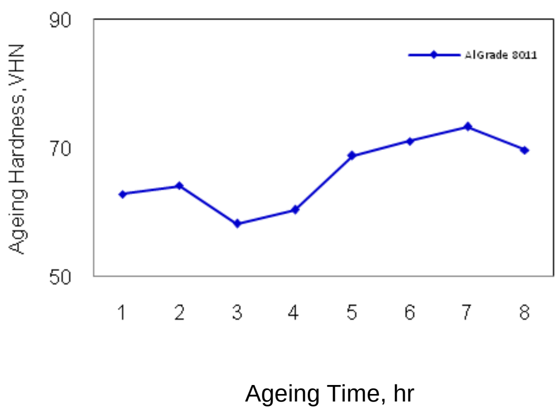

Fig. 9 Effect of ageing temperature at 190º C on Hardness of Al 8011

Fig. 10 Effect of ageing temperature at 210º C on Hardness of Al 8011

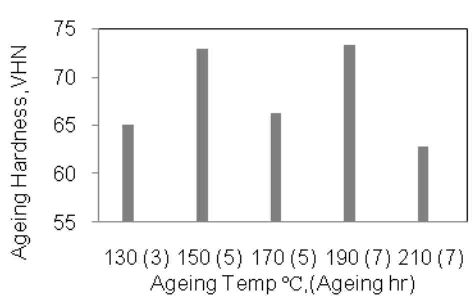

Fig. 11 Optimum hardness obtained for the values of various ageing temperature and ageing time.

The ageing hardness of each temperature from 130-210ºC for different ageing time intervals 1-8 hours has been attempted. From the Fig 13&14.The peak hardness for each temperature corresponding to ageing time is clearly noticed for both the alloys.

5. CONCLUSION

By conducting the heat treatment and hardness tests on Al 8011 composites, the following conclusion were drawn.

- As casted Al 8011 composites have resulted in lower hardness 55 VHN is obtained respectively.
- Precipitation hardened Al alloys have shown better hardness 73.33 VHN for Al 8011 alloys is obtained, when compared to as cast composite without heat treatment alloys.
- Mathematical modeling was done using ANN, and it is found that the theoretical and experimental hardness values were within the close tolerance limit and also the % error is found to be minimum and confirmed that the predicted model was adequate.
- The highest hardness experimentally found that 73.33 VHN for Al 8011 alloy at an aging temperature of 190º C at 7 hours is obtained.

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