*Int. J. Chem. Sci.: 14(S2), 2016, 453-460*
*ISSN 0972-768X*
*www.sadgurupublications.com*

# INVESTIGATION EXPLORATION OUTCOME OF HEAT TREATMENT ON CORROSION RESISTANCE OF AA 5083 IN MARINE APPLICATION

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## ABSTRACT

Aluminum alloy 5083 is commonly used in the ship building application in marine environment and susceptible to corrosion when they are run at high speed velocity, high flow rate condition and stagnate condition. Therefore, solution heat treatment was carried out to prevent corrosion. The optimal heat treatment involved heating specimens for 90 min at 400°C and then cooling them in water. In addition, the optimal artificial aging condition involved aging specimens for 120 min at 200°C. The corrosion rates of the heat treated specimens were determined using weight loss method. The immersion test has done for 2 weeks. The microstructures of heat treated specimens have been observed using optical electron microscope. The corrosion resistance of heat treated specimens increased after solution heat treatment and the hardness of the specimens also increased.

**Key words**: AA5083, Seawater solution, Heat treatment, Artificial aging.

## INTRODUCTION

5083 aluminum alloy is an alloy with magnesium and traces of manganese and chromium. It is highly resistant to attack by seawater and industrial chemicals. Its lightness coupled with its strength, conductivity, barrier properties and its excellent corrosion resistance is the most important advantages and the main reasons for the continued growth in the usage of aluminum alloy. The metal's excellent characteristics help give automotive and other transport users improved driving performance as well as increasing fuel economy and reducing emissions. Another significant advantage of aluminum alloy is its corrosion resistance. This characteristic is valuable for products used in architecture, construction, civil engineering, transport and many other applications. Aluminum alloy is used in many

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areas of transportation, shipbuilding and other harsh operating conditions. The alloys developed by these metallurgists as well as having excellent corrosion resistance are also weld able, which led to them being firmly established as a key construction material by ship and high speed ferry builders. In the case of stationary structures it offers reduced maintenance cost and decreased erection costs. But, aluminum alloys also suffer a little corrosion in the marine environment such as in the sea water. Therefore, this study is going to investigate the effect of heat treatment on corrosion resistance of aluminum alloy. The type of aluminum choose in this study is 5083 series aluminum alloys which is the most commonly used in marine application such as boats and ships. So it is necessary to investigate the effect of solution heat treatment on the corrosion resistance of aluminum alloys by using aluminum as a material for the experiments. Hosni Ezuber et al.[1] had experimented on the aluminum alloys were tested in seawater at two different temperatures. Polarization plots showed that the alloys suffered from pitting attack. The breakdown potential of the alloys decreased with an increase in test temperature with better corrosion resistance. The weight loss tests revealed low corrosion rate values for alloys, indicating a beneficial use for these alloys in marine environments. The results showed that the type of inter metallic particles in the aluminum alloy played a major role in passivity breakdown and pit morphology in seawater. K.C. Ho et al.[2] Age forming technique has been used in aerospace industry to manufacture panels components with improved mechanical properties and reduced fabrication cost. Age forming is based on the stress relaxation phenomenon due to creep, which occurs during the artificial ageing of a metal. Different from other metal forming techniques, ‘ageing–creep’ deformation takes place well below yield point and the amount of plastic deformation is directly related

## EXPERIMENTAL

To investigate the effects of heat treatment on corrosion resistance of aluminum alloys with different time of aging process. To determine the hardness of the aluminum alloys after heat treatment process. To determine the corrosions rate of the aluminium alloys by using immersion test method. To analyze the corrosion type occurs to the aluminium alloys. Solution heat treatment involves the heating of an alloy to a suitable temperature, holding at that temperature for sufficient time to induce one or more of the constituents to enter into solid solution and then cooling rapidly enough to hold these constituents in solution. Precipitation hardening or artificial aging is the process which one or more constituents precipitate from the solid solution to induce an appreciable increase in hardness.

The change in the mechanical, physical and chemical properties of metals and alloys resulting from the lack of thermodynamic equilibrium in the original state and the gradual

approach of the structure to the equilibrium state under conditions those permit a sufficient diffusion rate for the atoms. Upon rapid cooling from high temperatures in hardening or after crystallization and hot working metals and alloys retain either partially or completely the atomic structure characteristic of the high temperature scale state. In pure behavior of an aluminum metals, the irregularity of this structure consists in an excess concentration of vacancies for low temperatures and presence of other defects of the crystal structure. In alloys, the disequilibrium of the structure may be related to the retention of phases that are unstable at low temperatures. of greatest importance is the aging of alloys, which is caused by the decomposition of a supersaturated solution. The state of super saturation in a solid solution arises after cooling of alloys from high temperatures in as much as the solubility of admixtures or of specially introduces of alloying materials. Environmental conditions that should be created and the acceleration degree needed usually identify which laboratory tests should be used. Proper acceleration is obtained by the following in this test small batches of the material are subjected to the medium under testing, while loss of weight is being gauged for a particular period. The immersion test remains the most reliable method in terms of screening. It also serves as the most simple and economical way to determine the most suitable material to protect against corrosion in certain environments.

## Experimental setup and equipment's

Selecting four same material specimens for different experiment procedures and finding out the hardness of the material at each stage. Solution heat treatment process carried out initially. The material is Aluminum alloy 5083 is selected with 6 mm thickness. The dimension is Material dimension: 50 mm x 25 mm x 6 mm. Table 1 gives the chemical composition of aluminum alloy 5083.

**Table 1: Chemical composition of AA5083**

| Element | Cr | Fe | Mg | Mn | Si | Zn | Al |
|---|---|---|---|---|---|---|---|
| **Wt (%)** | 0.25 | 0.22 | 4.58 | 0.64 | 0.15 | 0.02 | 94.2 |

Solution heat treatment process heating the material up to 420°C for 90 min to improve the mechanical properties. After heating up to 420°C soaking it for 30 min. Then remove the material from furnace and quench it.

Then find out the hardness of the material. At each stage we have to find out the hardness of the material so that we can examine changes occurring at different stages. Fig. 1 represents the solution heat treatment process as shown above.

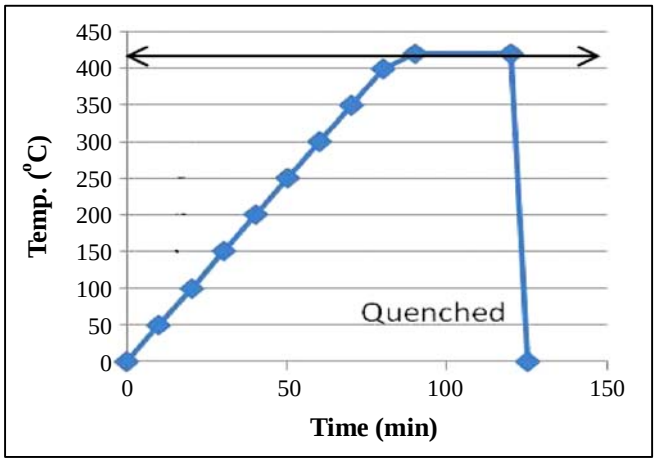


**Fig. 1: Solution heat treatment process**

Completion of solution heat treatment process next step is to artificial aging heat treatment to the materials. At this stage keeping the materials at elevated temperatures at 150 °C and 200°C as shown in Figure 2. So that we can improve the hardness for the material. Artificial aging done at two temperatures to know better hardness values and which stage has better mechanical properties. Artificial aging plays a key role in heat treatment process for regaining the structure due to vacancies and retention phases at low temperatures.

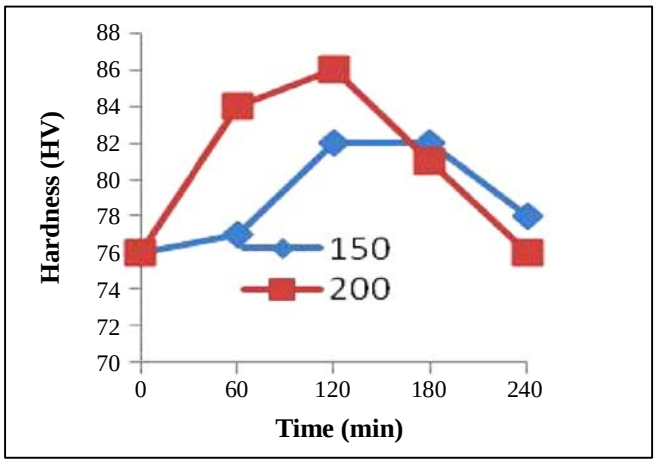


**Fig. 2: Hardness values of artificial aging at 150°C and 200°C for 240 min**

As received specimens hardness calculated initially the value is (HV 76). Four specimens are used at each aging temperature. After aging process hardness value is

calculated for four specimens. The specimens artificially aged at 150°C and 200°C after being heat treated for 420°C and then cooled in water. The greatest hardness was produced after artificial aging at 200°C of 120 min is (HV 86).

## Immersion testing

Immersion test method measures the progress of corrosion damage obtained from the immersion length within a corrosive environment, as well as other factors that can accelerate the corrosion process. This method is also called as weight loss test method. To determine corrosion rate of aluminium alloy we use immersion test method for this process which is better economical and efficient.

According to ASTM G31 immersion test method

To calculate the corrosion rate from weight loss test method:

$$mm/y = (W/D*A*T)$$

Where W = Weight loss of metal in milligrams D = metal density in $mg/mm^3$

A = Area of sample in $mm^2$ T = time (year)

To assess the effect of alloying elements on seawater pitting corrosion behavior of aluminum alloys. Aluminum alloys 5083 were tested at natural sea water at room temperature. Prior to test the samples were mechanically polished on a range of sic emery paper to a 1200 grit finish and washed in distilled water. Immersion test of AA5083 as received specimens were determined in Fig. 3. This represents the corrosion rate values.

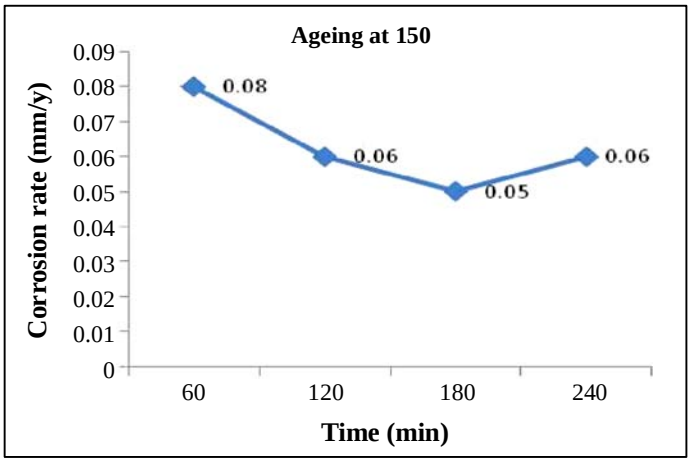


**Fig. 3: Immersion test of AA5083 for as received specimens for two weeks**

Immersion test of AA 5083 ageing at 150°C for two weeks shown in Fig. 4 compared to as received specimens aging at 150°C temperature the corrosion rate values slightly reduces because of intermetallic particles in aluminum alloys plays a major role in passivity break down. And also change in mechanical properties differs the corrosion values.

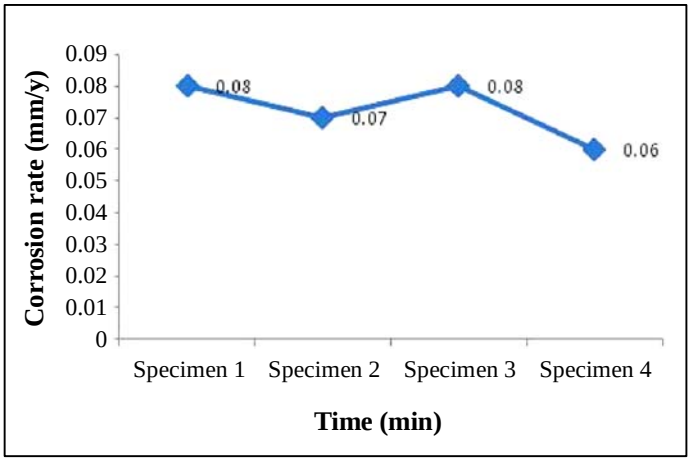


**Fig. 4: Immersion test of AA5083 ageing at 150°C for two weeks**

Immersion test of aluminum alloy 5083 of artificial ageing at 200°C for two weeks shown in Fig. 5. The weight loss tests revealed that alloy exhibit low corrosion rate values for heat treated specimens at this temperatures compared to as received and 150°C. At 200°C we got the low corrosion rate value because of greatest importance is the aging of alloys, which is caused by decomposition of super saturated solution.

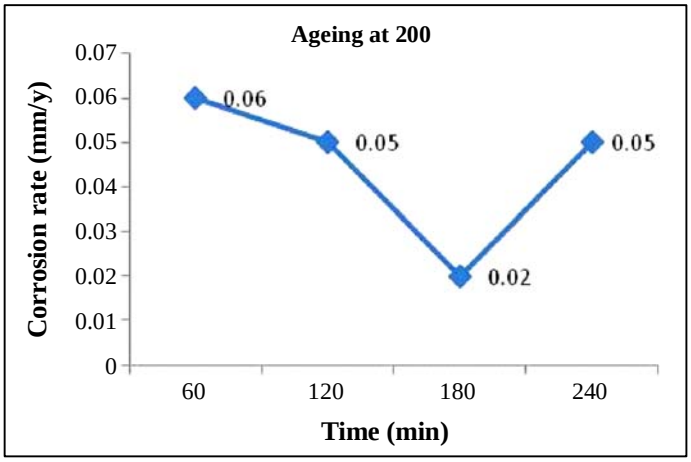


**Fig. 5: Immersion test of AA5083 at 200°C for two weeks.**

Specimens after immersion test at 200°C the specimen are revealed with shallow pits are shown in Fig. 6. In this figure specimen 3 reveals the low corrosion rate value because of change in mechanical properties.

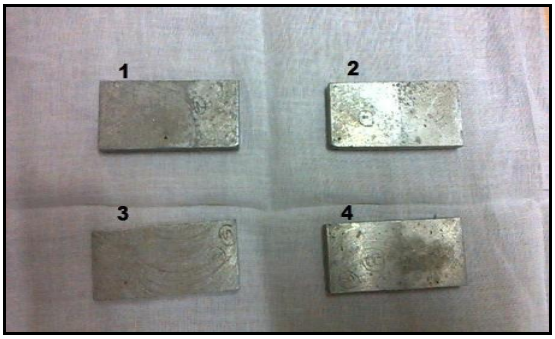


**Fig. 6: Specimens after immersion test at 200°C**

Micro structure of corrosion occurred material AA5083 after immersion test at 200°C is shown in Fig. 7. AA5083 suffered pitting corrosion type attack in sea water. By using optical microscope we analyzed the corrosion is pitting attack.

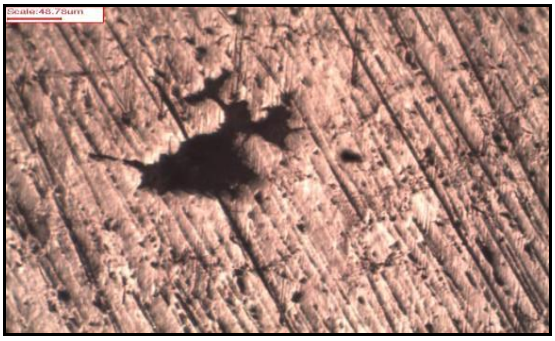

**Fig. 7: Aluminium Alloy 5083 micro structure after immersion test**

## RESULTS AND DISCUSSION

(i) The greatest hardness was produced after artificial aging at 200°C of 120 min is (HV 86).

(ii) Compare to as received specimens after solution heat treatment and artificial aging for the material the hardness value increases.

(iii) Immersion test for AA5083 revealed that pitting corrosion occurs.

## CONCLUSION

The weight loss tests revealed that alloy exhibit low corrosion rate values for heat treated specimens compared to the as received specimens. The results obtained in this study indicate that the type of intermetallic particles in aluminum alloy plays a major role in pit morphology of aluminum alloys in sea water.

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*Accepted : 01.07.2016*