Review on Secondary Treatments of Recycled Aluminium

Dr. C. Bhagyanathan* & G. Sathiya Seelan**

*Associate Professor, Department of Mechanical Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, INDIA.
**Student, Department of Mechanical Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, INDIA.
E-Mail: sachinseelang{at}gmail{dot}com

***Abstract*—**Materials after high temperature processes have varied properties. Secondary treatment of materials are required to improve the properties of the materials, one of the main secondary treatment is the cooling technique. The paper focuses on the various cooling techniques that are employed for the iron, steel and aluminium components and their effects on the material properties of the particular components. General heat treatment methods like annealing, normalizing, hardening, tempering and case hardening are discussed. The results obtained in the various papers were analyzed and the various gaps identified in the papers are discussed as the conclusions.

***Keywords*—**Cooling Technique; Heat Treatment; Metallographic Examination; Quenching; Trimming.

I. Introduction

ALUMINIUM is a chemical element in the boron group with symbol Al and atomic number 13. It is a shimmering white, delicate, nonmagnetic, pliable metal. Aluminium is the third most plenteous component (after oxygen and silicon), and the most bottomless metal in the Earth's outside layer. It makes up around 8% by weight of the Earth's strong surface.

Aluminium is astounding because of its low density and for its ability to resist corrosion due to the phenomenon of passivation. Auxiliary segments produced using aluminium and its compounds are fundamental to the avionics business and are vital in different territories of transportation and basic materials [Kolahdooz et al., 3].

Alloy BMg-1 is recommended for torch or dip brazing. Alloys BMg-1 and BMg-2a are used to braze AZ10A, K1A, and H1A alloys; AZ31B and ZE10A magnesium-base alloys can be brazed with the BMg-2a filler metal. In all cases, a flux must be used and residues removed after brazing to prevent corrosion.

Complex heat treating schedules, or “cycles,” are often devised by metallurgists to optimize an alloy's mechanical properties. In the aerospace industry, a superalloy may undergo five or more different heat treating operations to develop the desired properties [Digges et al., 4]. This can lead to quality problems depending on the accuracy of the furnace's temperature controls and timer. These operations can usually be divided into several basic techniques.

II. Methodology

2.1. Materials and Methods

Sand Moulds: Sand casting, the most widely used casting process, utilizes expendable sand molds to form complex metal parts that can be made of nearly any alloy.

1. Mold-making - The initial phase in the sand casting process is to create the mold for the casting. In an expendable mold process, this progression must be performed for each casting. A sand mold is formed by packing sand into each half of the mold.

2. Clamping - Once the mold has been made, it must be prepared for the molten metal to be poured. The surface of the mold cavity is first lubricated to facilitate the removal of the casting.

3. Pouring - The molten metal is maintained at a set temperature in a furnace. After the mold has been cinched, the molten metal can be scooped from its holding container in the furnace and poured into the mold.

4. Removal - After the predetermined solidification time has passed, the sand mold can simply be broken, and the casting removed.

5. Trimming - During cooling, the material from the channels in the mold solidifies attached to the part [Mohandass et al., 1; Wan Nik et al., 2]. This excess material must be trimmed from the casting either physically by means of cutting or sawing, or utilizing a trimming press.

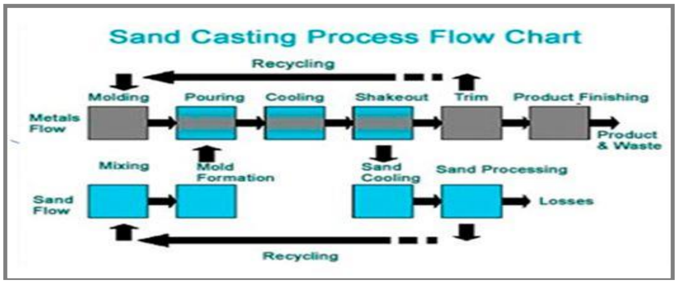

Figure 1: Process

There are six steps in this process:

1. Place a pattern in sand to create a mold.
2. Incorporate the pattern and sand in a gating framework.
3. Remove the pattern.
4. Fill the mold cavity with molten metal.
5. Allow the metal to cool.
6. Break away the sand mold and expel the casting.

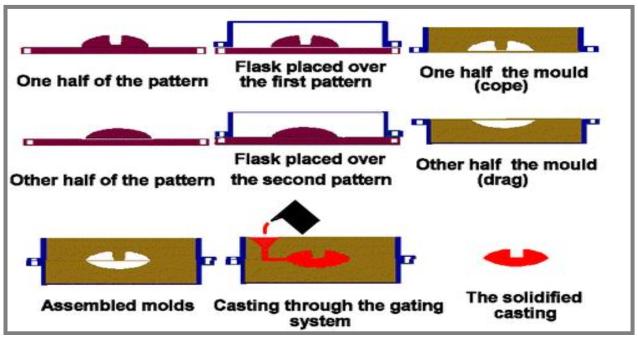

Figure 2: Casting Process

2.2. Heating Operation

A carbolite GLM3 model box furnace was used to heat the prepared samples to the selected solutionizing temperature of 4000C, 4500C, and 5300C. The samples were arranged in the furnace in such a way as to allow uniform circulation of hot air to all the specimens. Nine (9) samples were heated at every heating operation. A total of three (3) heating operations were conducted in each case.

2.3. Quenching Operation

After heating was completed, the various samples were quenched in water, shea-nut oil and palm oil baths respectively. The baths were agitated in order to increase the rate of heat transfer through the quenching process. After the completion of the quench, the samples were removed from the various mediums and sanding was done after each quench to maintain a consistent surface finish of the specimen throughout the experiments.

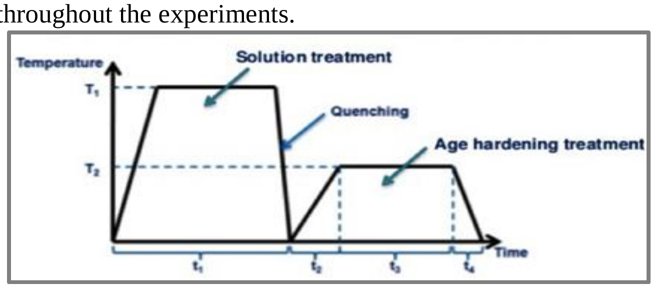

Figure 3: Effects of Various Heat Treatment [Abubakre et al., 8]

2.4. Testing Operation

Avery Denison T4CI/33470 model, 6705U/33458 model and 6408/33267 model machines were used to test for the tensile strength, toughness and Rockwell hardness respectively.

2.5. Metallographic Examination

The specimens for micro examination were prepared by grinding on hand grinding deck of abrasive papers of grades 240, 400, 600 and 1000. Polishing was done on a universal rotary wheels using alumina as the polishing medium. The thoroughly polished specimen was washed in warm water and swabbed with methylated spirit and dried using warm air. Etching was done in a solution of one percent (1%) Sodium Hydroxide in water by swabbing the polished surface of the specimen with the etching reagent. A Leitz model binocular metallurgical microscope (the bench type) was used to view the micro – structural changes that took place in all the prepared samples.

III. Results and Discussion

3.1. Tensile Test Result

The highest ultimate tensile strength values were obtained in samples quenched in water, sheanut oil, and palm oil at 5300C. The corresponding ultimate tensile strength was

Table 1: Impact Test [Abubakre et al., 8]

Quenching media	Temperature	Charpy Impact Values
Water	400	26
	450	27
	530	60
Sheanut Oil	400	49.6
	450	50.1
	530	65
Palm Kernel Oil	400	41.2
	450	42.2
	530	41
Control Sample	-	26

109.0N/mm2, 88.0N/mm2 and 90.1N/mm2 respectively. Similarly, the yield strength obtained was 70.89N/mm2, 66.72N/mm2, 64.94N/mm2 respectively. The values for the control system are ultimate tensile strength 83.8 N/mm2 and yield strength of 64.44 N/mm2.

Samples quenched in sheanut oil and palm kernel oil at 530oC showed a marginal increase in reduced strengths (ultimate and yield strength) when compared to the values for the control sample. However, the highest ultimate tensile strength of 109.7 N/mm2 was obtained with sample heated to 5300C and quenched in water.

3.2. Rockwell Hardness Result

The homogenous distribution of the fine precipitate of copper, in Aluminum matrix is largely responsible for the hardness of the quenched aluminum alloy. The hardness of the aluminum alloy specimens quenched in water, sheanut and palm kernel at a solutionizing temperature of 5300C increased [Kolahdooz et al., 7].

Table 2: Results of the Component at Various Temperatures [Abubakre et al., 8]

Quenching Media	Temperature	Solutioning Time	UTS	Yield Strength	% Elongation
Water	400	2	85.7	633	7
	450	2	87.6	67	6.11
	530	2	109.7	70	4
Sheanut Oil	400	2	78.12	59	6.35
	450	2	86.37	62	6
	530	2	88.0	66	3.75
Palm Kernel Oil	400	2	74.07	55	6.0
	450	2	77.04	57	5.5
	530	2	90.1	64	2.98
Control Sample	-	-	83.8	64	5

3.3. Microstructure Examination

This is associated with fine precipitates, which impact improved strength as compared to other specimens, which have a little coarse dispersion of precipitates. The changes in structure of the specimen are associated with the temperature of suctioning and the cooling rate of the quenching medium [Nes & Bjarne Nst, 5; Islam & Boswell, 6].

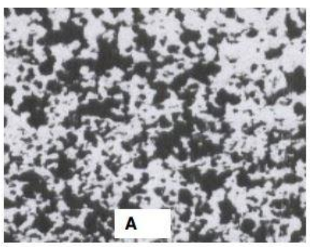

Plate 1A: Aluminum 6061 quenched in water at 530^{0}C. Precipitates formed by Si Mn and Mg spherodised in Al-matrix (mag x 300)

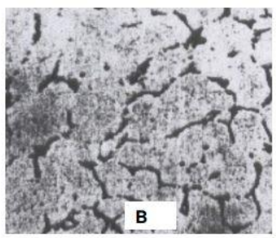

Plate 1B: Aluminum 6061 quenched in palm kernel oil at 530^{0}C, plate lets of precipitates sharing partial spherodisation (mag x 300)

Figure 4: Microstructure [Abubakre et al., 8]

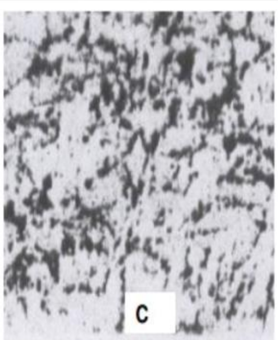

Plate 1C: Aluminum 6061 quenched in Sheanut oil at 530^{0}C showing growth of precipitates leading to sub grains of concentrated precipitates (mag x 300)

Figure 5: Sheanut Oil Quenched Microstructure [Abubakre et al., 8]

3.4. Identified Gaps in Paper

1. The reason why the material (aluminium) was heated again and then quenched is not mentioned.
2. If air cooling was performed the time period was not mentioned.
3. The engine oil cooling mentioned initially was not conducted.
4. The agitation provided for the quenching process, was it manual or machine operated is not clearly defined.

IV. Conclusion and Scope for Future Work

The similar process can be used and the material can be tested for quenching immediately. Maybe the material can be subjected to air cooling for a certain amount of time before being quenched in the respective liquid medium and tested for microstructure and chemical composition.

The recycled aluminium can be subjected to similar conditions to improve the mechanical properties and the effect of such process can be compared with the normal conventional recycling process. Analysis can be made whether there is a significant change in the strength of the material.

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