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Effect of Adding Degassing (Ar-N2) on Hardness and Microstructure of Recycling Aluminum Cans

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ABSTRACT

In this work the effect of degassing on hardness and microstructure of aluminum recycled cans using aluminum beverage cans scrap from different locations in Baghdad wastes had been studied. Aluminum cans were shredded and ground into small pieces. It was processed through a gas fired to eliminate the coated layer (paint or lacquer on the metal). Generally the scrap is divided into two groups before charging to the furnace, one without adding degassing and the other degased with (Ar-N2). When temperature exceed 690C° molten aluminum was pour into two molds, after cooling. The two ingots were expose to porosity test, hardness, and microstructure. It was found from recycled cans ingot behave like short freezing range alloys. The main form of shrinkage porosity is localized external sink, appeared at the heat centers or at last region to be solidify. This had been verified clearly by microstructure of many regions of the ingot without adding a degasser. Either defect or decrease in hardness was clearly seen in the ingot without degassing addition. In addition to oxides, a number of additional compounds could be considered inclusions (intermetallic phase particles) in cast structures. Where the main conclusion was to remove gases without using a degassing to ingot decadence on the first gas fire on the cans to remove all paint or lacquer on the metal, but this was not sufficient and properly we need to add degassing to ingots. Finally this was clearly shown from the results of the ingot with adding a degassing had 89 kg/mm2 HV rather than 61 kg/mm2 for ingot without degassing.

1. Introduction

In recent years, the world has witnessed a revolution in the recycling of all industrial waste and consumables, including aluminum cans. Recycling accounts for 95% of the energy, which is a significant number, as well as environmentally friendly and healthy materials. According to statistics, as shown in figure (1), there is a significant difference in the energy economy.

In addition the Use beverage recycling Cans (UBCs) was rate: 30% is Hypothetical low (UBC recycling rate), 45.1% was estimated by container Recycling Institute (CRI) in 2008, 62% was the Peak which achieved during the mid-1990s and 75% was the Al. Association future goal for (UBC recycling rate).[1]

Previous work by Humberto, etl. (2006) [2], Focused on method of Removal Iron from Molten Recycled Aluminum using ceramic filter, final results they get efficiently removed by iron through the use of manganese and silicon followed by decreasing temperature at which the intermediate phases crystallize, but they neglected the cooling rate effect beside the temperature that they take in response. Also Salem, etl. (2013) [3] studied some role of (Cu) on (Al-Si-Mg) alloys, taken the range of (0–5) wt. %, in the as-cast conditions that qualitatively on microstructure, defect formation, porosity and

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strength. Finally porosity level was unaffected conversely tensile strength was improved at the expense of ductility but no mention about temperature effect.

Finally Maria, etl (2017) [4] Studied the solidification rate effecting in the microstructure of (Al-Si5Cu3) alloy, the cooling rate influence on the formation of iron compounds by thermal analysis and metallography had been investigated. As a final results the high cooling rates, between (10-103) K/s, could be able to reduce and nullify the formation of needle such as (β-Al5FeSi phase), and help the formation of the Chinese scripts (α-Al15(Fe, Mn)3Si2 phase). By analyze the curves it had been reveals that increase the cooling rate increases the temperature of nucleation of the (α-Al dendrite) and decrease the eutectics phases of (Al-Si) & (Al-Cu).

The aim of the present work is to study the effect of degassing addition on hardness and microstructure of aluminum recycled cans ingots compared with ingots without degassing.

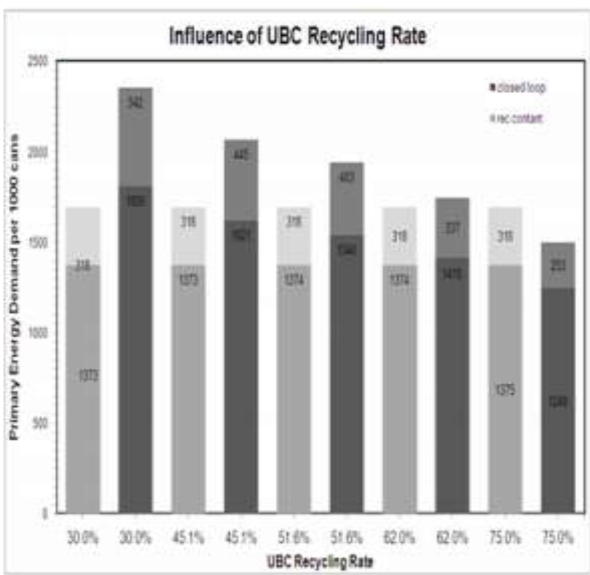

Figure (1): Variation of primary energy rates for closed loop and recycled content approaches. [1]

2. Theoretical Concentration

2.1. Recycling of Aluminum Cans

Industrial recycling programs of Aluminum recycling cans based on minimizing capital costs. The efficiency of recycling programs could be improved by increasing the collection of aluminum, waste reduction based collection systems such as pay as you throw, and this is clearly seen in UK last 18 years as shown in figure (2).

Aluminum beverage cans manufactured from two alloys (main body: 3004 ASTM and lids: 5182 ASTM) [6].

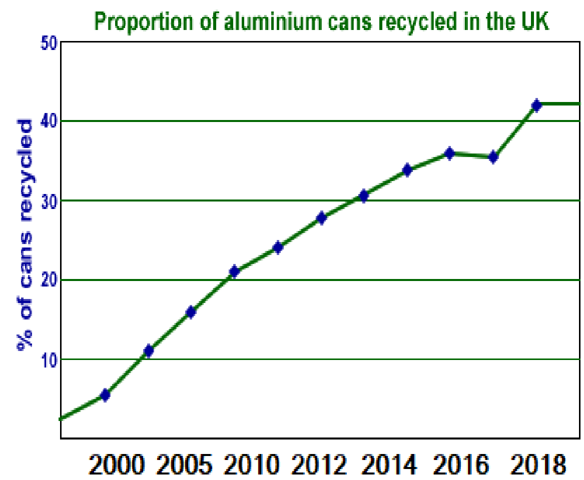

Figure (2): proportion of Aluminum can recycled in UK [5]

2.2. Degassing

Defects in castings or ingots impairs both their mechanical properties and corrosion resistance, the main causes of castings rejection in foundries is porosity. Gas holes or shrinkage defects usually classified by Foundry men, but in fact, they are usually a combination of both.

The main source of gas porosities in these ingots is hydrogen. Aluminum castings usually contain (0.15–0.30 ml H2/100 mg Al). Hydrogen concentration needs to be kept below 0,1ml H2/100 mg Al. in high-strength casting alloys. Although, shrinkage porosities shown more in casting with low hydrogen content than those with higher concentration levels, and require much more accurate gating and feeding systems calculation [6].

2.3. Traditional Degassing Methods

Hydrogen is present in atomic form in liquid aluminum, not as molecular hydrogen (H2). Difficulties is present to remove the hydrogen when its atoms form as gas molecules. To solve the problem of gas bubbles (usually argon or nitrogen) are introduced in the melt, using either a diffuser head coupled to a rotary shaft, or by inserting hexachloroethane (C2Cl6) tablets in the melt. Hydrogen atoms like bubbles can then diffuse, where the reaction (1) can easily proceed to form hydrogen gas which is expelled into the atmosphere and when the bubbles rise to the melt surface.

H+H→ H2 ……. (1)

Reducing the pressure inside the melting chamber to remove the hydrogen from aluminum as creating a small vacuum effect that increases the hydrogen removal rate, is a required technique known as vacuum degassing.

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3. Expermental work

This work has been divided into three stages.

1- The preparation of cans, mold and casting

2- Porosity and hardness test.

3- Microstructure inspection of the recycled aluminum cast

Stage one:

The preparation of cans, mold, casting and degassing addition:

Mostly beverage cans consist of the sheet body and the led, it has different size but the most commonly used in Iraq is the size 330 ml. Using the Vernier Caliper the thickness of the sheet body about 90 micrometer with a diameter about 65 mm. Using Digital Sensitive Balance the weight of an empty aluminum cans is about 15g. This helps us to laminate the amount of molting process. The chemical composition was done by SEM device (Tescan VEGA 3 SB) in university of technology- Nano technology center. Table 1 shows the chemical composition of the can sheet body and lids. Aluminum cans are shredded into small pieces and burned to remove the paint. Two molds are used in this process, one ith adding (Ar-N2) gases while the other without gas addition. The mold made of grey cast iron with the dimensions shown in figure 3. All figures and tables should be numbered with.

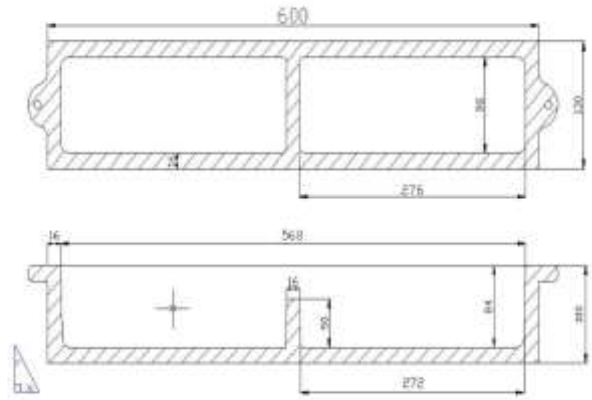

Figure 3: the ingot mold.

Figure 3: the ingot mold.

In order to ensure that no interaction with the aluminum occurred during the solidification, chemical composition of mold was done by SEM device (Tescan VEGA 3 SB) in university of technology-Nano technology center and illustrate in the table 2.

Table 2: the chemical composition of the mold

C %	Cr %	Fe %	Mg %	Mn %	Mo %	Ni %	P %	S %	Si %
3.72	0.95	91.9	<0.002	0.66	0.59	0.19	0.09	0.032	1.89

Table 1: chemical composition of the can sheet body and lids

Composition &Typically alloy	Cu%	Fe%	Mg %	Mn %	Si%	Zn%	Al%	rest%
ISO AlMn1Mg1;Aluminum 3004-H19;AA3004-H19	<= 0.25	<=0.70	0.80-1.30	1.0 -1.50	<= 0.30	<= 0.25	95.5 - 98.2	<= 0.25
UNS A93104;Aluminum 3104-H19; AA3104-H19	0.050-0.25	<= 0.80	0.80- 1.30	0.80- 1.40	<= 0.60	<= 0.25	95.0 - 98.4	<= 0.15
AA5182-H19 5182-H48	<= 0.15	<= 0.35	4.0 - 5.0	0.20- 0.50	<= 0.20	<= 0.25	93.2 - 95.8	<= 0.15

The aluminum cans is melt in electrical furnace with max. Temperature of 750C°. Argon and Nitrogen solubility in solid and liquid aluminum is shown in Figure 4.

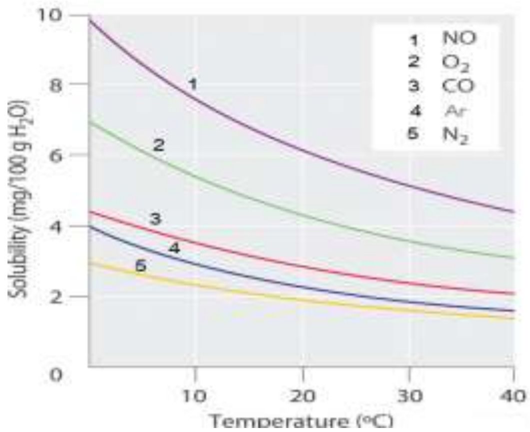

Figure4: Solubility of Argon and Nitrogen in solid and liquid aluminum. [5]

Final ingots after cutting side of the specimen for the proposal work as shown in figure 5.

After producing the ingot, it has been cut into smaller part in order to check the hardness and microstructure.

Stage two: hardness test:

Hardness test: The hardness of two ingots were measured by using Vickers micro hardness tester type (TPμPA, HV- 1000). The average of (5reading) was taken. All hardness values were taken at a load of (1kg) as shown in table 3.

Table 3: the Vickers micro hardness

No.	Ingot specification	HV
1	ingot with degassing	89 kg/mm2
2	ingot without degassing	61 kg/mm2

Stage three: microstructure of recycled aluminum cast

Figure 6, 7: show the microstructure of the ingots with and without degassing respectively.

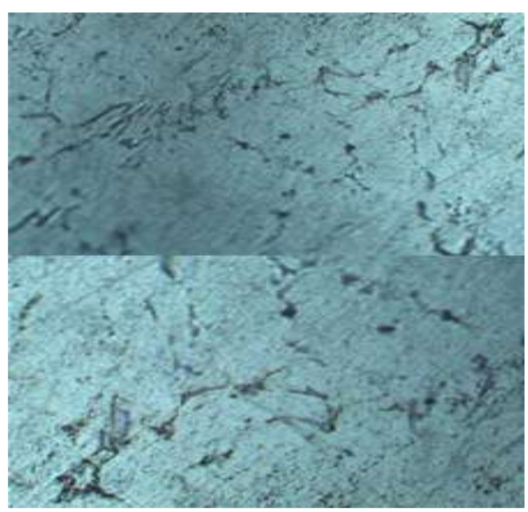

Figure6: shows the microstructure of the ingots with degassing.

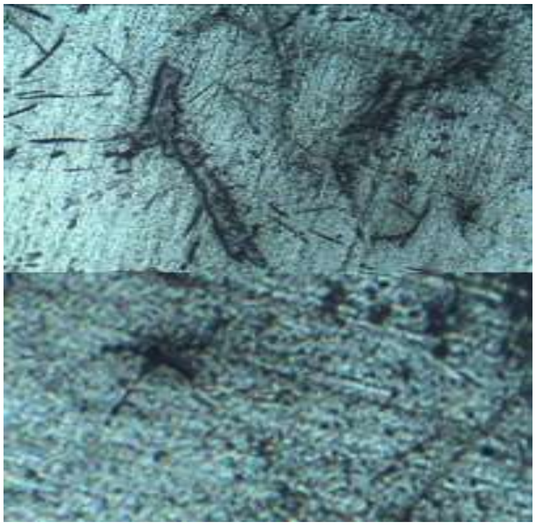

Figure7: shows the microstructure of the ingots without degassing.

4. Results & Discussion

From the present work, it can be seen that the cast with degassing has a better properties (hardness and microstructure), this work tried to produce an ingot from recycled aluminum cans without using degassing depending on first stage of pouring (gas fired to eliminate the coated layer paint or lacquer on the metal).Results found that the gases were not expelled by comparison between two ingots. Hardness value for the ingot with degassing addition was 89 kg/mm2 compared with ingot without degasser was 61kg/mm2. Microstructure that showed the presence of black color as a defects in cast. Additions of degassing in important in aluminum recycling cans to eliminate hydrogen bubbles in the final ingots. To access a perfect ingots free of defects.

5. Conclusion

This work tried to produce an ingot with perfect properties using first stage of pouring (gas fired to eliminate the coated layer paint or lacquer on the metal) only without adding a degasser to molten ingot. Recycled beverage cans alloy behave like short freezing range alloys Degassing that, the main form of shrinkage porosity is localized external sink, appeared at the heat centers or at last region to be solidify. Hardness value for the ingot with degassing addition was 89 kg/mm2 compared with ingot without degasser was 61kg/mm2

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