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Aluminium Silicon Hypereutectic Alloys from 6063 Alloy's Black Dross Using Silicon Lumps and Flux

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Abstract

The study on the extraction of Aluminium metal from industrial waste like aluminium dross (black dross) to be used in the production of aluminium silicon hypereutectic alloy and testing the resulted hypereutectic alloy chemically, physically, and mechanically has been carried out. The amount of the black dross used undergoes pretreatment by immersion the dross samples in tap water and settled overnight to assure the maximum separation of nonmetallic, aluminium nitride, aluminium carbide and aluminium oxide, the properties of tap water used for pretreatment dross samples was recorded to see the effect of dross content on the tap water. The pretreated dross samples were dried in electric furnace at 60°c for 2hrs then samples of 60 gm remelted in a graphite crucible and amount of flux(sodium chloride, potassium chloride, cryolite and calcium fluoride) (1:1) is added, then different quantities of silicon lumps are added too. The graphite crucible is put in the carbolite furnace at 800°c for 30 minutes. The molten aluminium silicon is poured in specific moulds for the chemical and physical examination, which shows the formation of aluminium silicon hypereutectic alloys with good chemical, physical and mechanical properties. Thus the dross is a great source for both aluminium metal high grade and aluminium silicon hypereutectic alloy.

Keywords: Aluminium secondary dross black dross, Fluxes, Silicon, Hypereutectic, 6063 alloys.

Introduction

Aluminium dross identifies as a by-product forms during the aluminium production industry which contains significant quantities of aluminium metal (up to around 70%). Most drosses are a heterogeneous mixture of large lumps, fine oxides and small pieces of metal. Aluminium dross is a combination of free metal and nonmetallic substances (e.g. aluminium oxide and salts). Aluminium nitrides and carbides may also be present, as well as metal oxides derived from the molten alloy [1]. It has also been documented that dross should be stored in a dry environment since reactions of carbide or nitride of aluminium and calcium can form acetylene and ammonia [2]. Drosses may be classified by means of their metal content. Drosses with a high metal content (white, or wet, dross that is rich in free metal) typically occur as a compact material in large clotted lumps or blocks. A low metal content typically occurs when scrap is remelted with salts in an open hearth furnace. This black, or dry, dross is usually granular with a high metal content in the coarse fraction and chiefly oxides and salt in the fines [1].

General discussions of the treatment of drosses and related products have been given by Bahr and Kues [3] and Shen and Forssberg [4]. Characterisation work has been reported by Hagni [5], Manfredi, Wuth, and Bohlinger [6], and Bruckard and Woodcock [7]. Data on the recovery of aluminium by comminution and sizing have been presented by Fair et al. [8] and by electrostatic separation by Mah, Toguri, and Smith [9].

Flotation of aluminium from dross has been reported by Soto and Toguri [10] and Bruckard and Woodcock [7]. The present paper discusses the production of aluminium metal high grade as the aluminium metal high grade produced from alumina electrolysis, the aluminium metal from dross is then used to produce aluminium silicon hypereutectic alloy with good chemical, mechanical and physical properties.

Experimental

Sample preparation

Black dross samples (6063 alloy's black dross) are taken from the Aluminium company of Egypt, these samples immersed in tap water (PH = 7.5 & Conductivity = 0.35 μ Mohs & T.D.S = 178 mg /L) to get rid of the nonmetallic oxides then settled overnight to assure the maximum removing of these nonmetallic oxides, the treated samples were dried in an electric furnace at 60°c for 2hrs **(Figures 1 and 2)**.

Figure 1: Black dross (Aluminium company of Egypt).

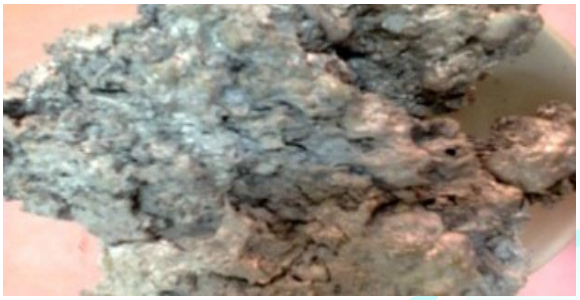

Figure 2: Treated black dross (after immersion).

Procedures

The treated dried black dross samples are re-melted in graphite crucibles in the presence of flux with adding amounts of pure silicon lumps in carbolite furnace at 800^{o}c for 30 minutes. The molten Al-Si hypereutectic alloy poured into specific moulds for chemical and physical examination.

Tensile test

Standard tensile test specimens were also prepared in accordance to ASTM B557M "Methods for Tensile Testing of Metals" and their tensile strengths determined using ZWICK / ROELL Z 150 TL. The elongation was determined for each sample.

Hardness test

By Wolpert DIA – TESTOR 3 b: An indenter (hard metal ball with diameter D) is forced into the surface of a test piece and, after removal of the force F, the diameter of the indentation d left in the surface is measured. The Brinell hardness is proportional to the quotient obtained by dividing the test force by the curved surface area of the indentation. The indentation is assumed to retain the shape of the ball, and its surface area is calculated from the mean indentation diameter and the ball diameter.

Microstructural analysis

The microstructures of the samples were observed and taken using Olympus E330 – ADU1.2X.

Results

The chemical composition of 6063 alloy that black dross samples were taken from to recover aluminium metal and produce aluminium silicon hypereutectic alloy **(Table 1)**.

The aluminium metal recovered from black dross samples that could react with silicon lumps is up to 82% of the immersed and dried samples, the presence of the flux and the lumps shape of the silicon used increase the reactivity of the silicon with aluminium molten and the flux also protects both of silicon lumps and aluminium metal from oxidation, the lumps shape of the silicon causes the silicon to sink in the molten aluminium and thus protects the silicon from oxidation too **(Table 2)**.

Mechanical properties and microstructure of Al Si hypereutectic alloy (Tables 3 & 4)

Sample Name	Gauge Ln	Weight	Cross Section	Max.Load	Tensile Strength	Elongation
	(mm)	(gm)	(mm 2)	(kg)	(kg/mm 2)	(%)
Al Si hypereutectic alloy from 6063 drosses.	200	100.2	113.04	995.1	8.775	1

Table 3: Tensile strength & Elongation for the Al-Si hypereutectic alloy by using zwick / roell z 150 TL.

Sample No	Hardness. Brinell N/mm2
Al Si hypereutectic alloy from 6063 dross	72.7

Table 4: Hardness in Brinell for the Al-Si hypereutectic alloy by wolpert dia – testor 3 b.

Microstructure of Al-Si hypereutectic alloy from 6063 dross (Figure 5)

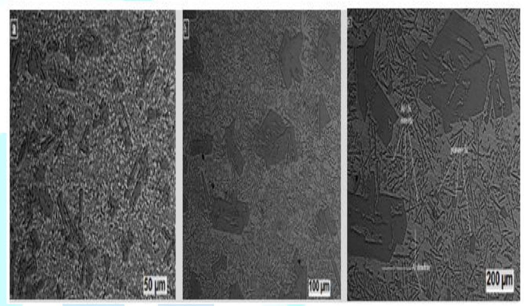

Figure 5: Optical microscopic images for Al-Si hypereutectic alloy.

Analysis of Al Si alloys by XRD-D4 endeavor broker (Figure 6 & 7)

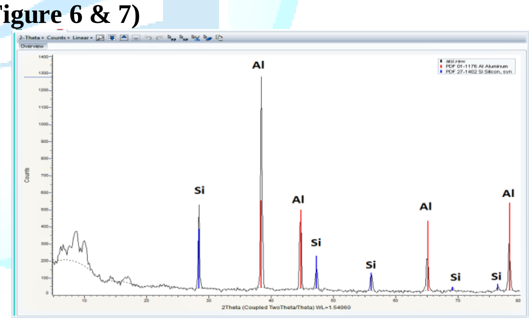

Figure 6: XRD pattern for the Al-Si hypereutectic alloy

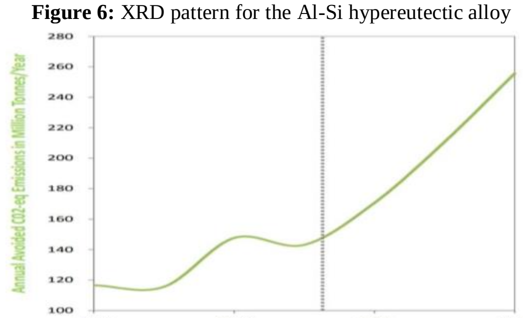

Figure 7: Annual avoided emission by Aluminium recycling
Note: CO_2 emission data for primary aluminium don't include China.

								Others	
Alloy	**Si**	**Fe**	**Cu**	**Mn**	**Mg**	**Cr**	**Zn**	**Ti**	**Each**	**Total**
6063	0.20-0.6	0.0-0.35	0.0-0.10	0.0-0.10	0.45-0.90	0.0-0.10	0.0-0.10	0.0-0.10	0.0-0.05	0.15

Table 1: Chemical composition of 6063 alloy which the black dross was taken from.

Sample	Si %	Fe%	Mn %	Mg%	Ni %	Na %	V %	Ti %	Zn %	Ca %	Al %
1	17.84	0.36	0.0063	0.0058	0.0017	0.0001	0.006	0.0211	0.005	0.0001	Balance
2	16.21	0.37	0.0057	0.0046	0.0003	0.0001	0.0049	0.0209	0.004	0.0001	Balance
3	16.86	0.36	0.0058	0.0046	0.0003	0.0001	0.0052	0.0211	0.006	0.0001	Balance
4	16.15	0.4	0.0058	0.0046	0.0003	0.0001	0.0046	0.0202	0.005	0.0001	Balance

Table 2: Chemical composition of Aluminium Silicon hypereutectic from dross, silicon lumps and flux by ARL 34000 optical emission quantometer.

Discussion

The chemical composition of the Al-Si hypereutectic alloy in **Table 2** shows the silicon content in the alloy which indicates the success in formation of the Al-Si hypereutectic alloy from the aluminium metal recovered from 6063 alloy's black dross and pure silicon lumps, the presence of flux plays an important role to protect both aluminium metal and silicon from oxidation, and saves a good barrier to prevent the recontamination of the alloy with the nonmetallic presents surrounding the hypereutectic alloy.

The flux reduces the impurity elements, like Na, Ca, and shows a great decrease in the Mg content in the hypereutectic Al-Si alloy. The mechanical examination, tensile strength, elongation and the microstructural images show good properties, and the microstructural images show the hypereutectic Al-Si alloys without the presence of flux particles in their layers after solidification due to difference in densities between the alloy formed and the flux with nonmetallic oxides.

Conclusion

It is established that 6063 alloy's black dross is a great source for aluminium metal high grade instead of being dumped and landfilled which affects the environment, the soil, the underground water and the aluminium industry itself, this dross is used to produce aluminium silicon hypereutectic alloy with the presence of flux to get rid of nonmetallic oxides and to protect the aluminium metal and silicon lumps from oxidation. The Al-Si hypereutectic alloy produced shows good mechanical and microstructural properties. The flux reduces the impurity elements, like Na, Ca, and shows a great decrease in the Mg content in the hypereutectic Al-Si alloy.

Acknowledgments

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