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RECORDS ADMINISTRATION
AFGK

AIR-MELT RECOVERY OF LITHIUM-ALUMINUM SCRAP

C. L. Selby

July 1959

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Introduction

In October 1957, a 250-pound capacity, 100-kilowatt induction furnace was installed in Building 320-M for use in recovery of Li-Al scrap. About 150 tons of such scrap had accumulated since startup of the Li-Al process. Additional solid scrap is being continuously generated at an average rate of about 10% of all metal charged. Scrap consists of ingot croppings, extrusion butts, rejected billets, and bar stock. Most of this scrap could not be recovered previously since the majority of scrap shapes would not fit into the charging mechanism of the vacuum induction furnace.

This report describes results obtained in evaluation of processes for recovery of scrap by induction melting in air.

Period Covered: October 1957 to March 1959.

Summary

Three production processes for recovering scrap by air-melting were evaluated. These processes and the results of the evaluations are listed below.

1. Slugs Made from Air-Melt Scrap. The air-melt alloy was cast into 100-pound ingots, extruded, and canned according to normal procedures.

   Direct use of this process was not adopted although it was the most economical process. A small reduction in the tritium yield of irradiated slugs, resulting from possible contaminants in air-melt alloy, might not be detected by the Separations Department. Such a reduction in yield would negate the 300-Area savings.

2. Extrusion and Vacuum Remelting. Air-melt alloy was cast into 100-pound ingots, extruded into bar, and cut into a size suitable for charging into the vacuum furnace. This process was not adopted because it was more costly than pigging (see next paragraph).

3. Pigging. Pigs weighing about 3 pounds (the same size as aluminum pigs used in the vacuum furnaces) were cast and charged into virgin Li-Al heats in the vacuum furnace. Pigging was adopted as a production process for recovery of Li-Al alloy scrap. Of 75,000 pounds of metal charged into the air-melt furnace, 92% was recovered in the form of pigs. Contaminant level of Li-Al alloy pigs, with few exceptions, was found to be within the same range as vacuum-cast alloy.

Air-melt pigs were charged into the vacuum furnace to produce vacuum-melt heats containing up to 100% recovered scrap. Analytical data have been obtained for heats containing 10% and 20% scrap. Due to changes in production scheduling, billets made from 100% scrap have not been extruded. The processing characteristics and purity of this material will be reported at a later date.

Casting and Processing

The three methods evaluated for recovery of Li-Al scrap are described in the following paragraphs. Specific details of all work performed on the two unsuccessful processes are not included.

All evaluations were performed using the 100 kw induction furnace installed for production recovery of scrap alloy. This furnace is shown in figure 1. Details of the furnace installation are shown in figures 2 and 3.

Slugs Made from Air-Melted Scrap

Sixty 100-pound ingots of air-melted Li-Al were cast and extruded into bar stock. Of 6000 pounds of bar extruded, 20% was fabricated into finished slugs (1088 slugs) according to standard procedures.

The major cause of slug rejection was hydrogen content in excess of the 6.5 vol % specification. Hydrogen content of slugs averaged 7 vol % compared with 2.5 vol % for vacuum-melted alloy.

Argon bubbling of the melt was tested as a means to reduce hydrogen content of the molten alloy. As is shown below, bubbling had no effect on hydrogen content.

Type Heat	No. of Billets	Avg H_2 Content of Billet, vol %
Bubbled	12	7.25
Unbubbled	12	6.90

Chlorine bubbling and chemical fluxes were not tested due to safety considerations and purity requirements of Li-Al alloy.

Further development of this recovery process was discontinued. The possible 300-Area savings were considered small compared to the cost of small undetectable decreases in 200-Area tritium yields which could occur from possible contaminants in the alloy.

Cans were removed from slugs produced during this development. The cores and the unmachined bars were remelted.

Extrusion and Vacuum Remelting

Casting ingots, extruding, and cutting the extruded bar to a size suitable for recharging into the vacuum furnace was found to be economically undesirable. The savings obtainable were about equivalent to the recovery costs.

Pigging

Casting alloy into 3-pound pigs suitable for recharging into the vacuum furnace was found to be the most acceptable recovery method. In this process, clean, dry, Li-Al scrap is charged into the cold furnace crucible. Furnace power is then applied. As the scrap starts to melt, additional scrap is added to provide a furnace charge of about 250 pounds of alloy.

After melting, the alloy is induction stirred, skimmed of dross, and ladled into cast-iron pigging molds. Each mold has a capacity of twelve 3-pound pigs. Seven molds are used.

Furnace power settings for a normal melt cycle (starting with the crucible and charge at room temperature) are shown below:

Sequence	Furnace Power, kw	Time at Power, minutes
Startup	10	20
	20	15
	30	15
	40	30
	50	30
Begin Melting	80	20
Complete Melting	0	5
Before Pouring	80	5

Recovery yields are about 90% for remelting bars and cores, and 85% for remelting croppings and extrusion butts. Loss is primarily from dross.

Dross Reduction

Argon blanketing of the melt surface was evaluated as a means to reduce drossing. In initial tests, argon was first circulated through a loop of tubing around the top of the furnace crucible. The argon then escaped from the inside of the loop through small jets which directed the gas over the melt surface. This technique was unsuccessful. Convection currents from the heat of the melt prevented the argon blanket from providing protection. By covering the entire top of the furnace with an asbestos hood, the argon blanket was held in place. However, no significant reduction in drossing was achieved. The hood also prevented normal access to the melt necessary for skimming and ladling operations.

Since neither of the above techniques was satisfactory, no further work was done. No additional methods for argon blanketing are under consideration at this time.

Impurity Content

Impurities, with the exception of iron, manganese, lead, and silicon, were not present in significantly higher quantities in cast pigs than in normal alloy. The increase in iron, manganese, and silicon content is attributed to pickup from the clay-graphite crucibles. The increase in lead content probably resulted from the recycle of alloy produced during the Mark VI-A fuel-development program in Building 320-M. At that time, lead oil was used as an extrusion lubricant for fuel-tube fabrication. Some of this lead oil apparently remained in the extrusion press and caused slight contamination of the Li-Al alloy. Extrusion of these fuel tubes in Building 320-M was discontinued in late 1957.

An estimated 15 to 20 tons of scrap with slight lead contamination is mixed in with 150 tons of scrap in the stockpile. The average lead content of the entire stockpile probably does not exceed 6 to 7 ppm.

When remelt pigs were added to virgin Li-Al heats, the concentrations of most contaminants present were unchanged. Exceptions were again iron, manganese, lead, and silicon. Analytical data are summarized in the following table. Data for commercial 1100 aluminum are included for comparison.

	No. of Heats		Impurity*, ppm							Hydrogen, vol %
			Ag	Cr	Cu	Fe	Mn	Pb	Si	
Normal Vacuum Furnace Alloy	67	Avg	<2	11	25	150	2.5	<4	40	2.5
		Rng	0 to 10	0 to 20	0 to 60	0 to 600	0 to 10	0 to 80	<40 to 200	0 to 8
Air-Melt Pigs	71	Avg	1	12	28	293	5	9	100	-
		Rng	0 to 3	0 to 40	10 to 60	50 to 500	1.5 to 10	0 to 100	<40 to 400	
Normal Alloy Containing:										
10 wt % Scrap	19	Avg	1.3	<10	27	175	4.2	<4	207	3.7
		Rng	0 to 5	-	15 to 60	80 to 400	1.5 to 8	0 to 5	<40 to 400	0.3 to 6.5
20 wt % Scrap	30	Avg	1.3	<10	32	328	5.2	18	135	3.2
		Rng	0 to 5	-	15 to 110	40 to 600	1 to 10	<4 to 80	<40 to 600	0.5 to 6.5
1100 Aluminum (2S)	Normal		-	120	1000	4000	100	-	1000	
	Maximum		500	500	2000	10,000 (Fe+Si)	500	500	10,000 (Fe+Si)	-

* No difference was detected in the impurity levels of B, Ba, Be, Bi, Cd, Co, Mg, Mo, Nb, Ni, Sb, Sn, Ti, Tn, Zn, Zr.

Experimental Work

Results of tests performed in selection of crucible and mold materials are described in the following paragraphs. This work was done concurrently with the evaluation of recovery methods.

Crucible Evaluation

Materials. Crucibles of high (Dixon C-7) and low (Dixon XU841D) conductivity clay-graphite were evaluated in the air-melt furnace. Low-conductivity material was the most acceptable from an induction heating standpoint as the furnace was designed for this type crucible. However, the low-conductivity material was less impervious to penetration of alloy and cracked severely by the 14th to the 20th heat. Cracking may also have occurred because the walls of the low-conductivity crucibles drew less power and did not get as hot. More dross settled on the walls causing strain due to differential expansion of the clay-graphite and the dross.

High-conductivity crucibles were undamaged after equivalent exposures. Improved performance resulted because the high-conductivity material was more impervious to molten alloy and because the crucible walls became hotter, preventing dross accumulation. However, these crucibles introduced the following problems:

1. Lower-power application, resulting in extended melt times, was required to prevent overheating of the crucibles.

2. Because this material improved crucible-to-coil coupling, the minimum power available from the autotransformer was increased. This change prevented fine control of charge temperature.

3. The maximum power that could be applied was lower because insufficient capacitors were available for power-factor correction.

Power-factor correction was obtained by installing more capacitors. Finer temperature control was obtained by making available a higher turn-ratio on the autotransformer.

Characteristics of high and low conductivity crucibles are compared in the following tables. Performance characteristics are based on continuous use of the air-melt furnace when crucibles do not cool significantly between heats. When crucibles must be heated from room temperature, longer melting times at lower power are necessary to prevent thermal damage to the crucibles.

Physical Constants of Crucibles

Conductivity and Material	Resistivity, ohms/cc	Conductivity as % of Graphite	Power Draw by Crucible, %
High (C-7)	5 to 10	60 to 65	80
Low (XU841D)	15 to 20	30 to 40	45

Performance Characteristics of Crucibles

Conductivity and Material	Power, kw		Melt Time, min	Crucible Life, no. of heats
	At Startup	Maximum		
High (C-7)	25	75	90	20 to 24
Low (XU841D)	55	100	70	14 to 20

Design. Crucibles with bottom-pour spouts (see figure 4) were evaluated as a means for reducing dross and inclusions in ingots. No improvements were noted. As the spout frequently became plugged with dross or cold metal, tests were discontinued.

The standard pot-type crucible was the most satisfactory crucible tested.

Mold Evaluation

Materials. The only molds tested for ingot casting of air-melt alloy were graphite molds. These molds performed as satisfactorily in air as in the vacuum furnaces.

Cast-iron pigging molds were satisfactory for casting 3-pound Li-Al pigs. The use of mold washes was found unnecessary. Molds were sandblasted to remove rust before they were placed in service. Preheating of the molds before pouring was not required.

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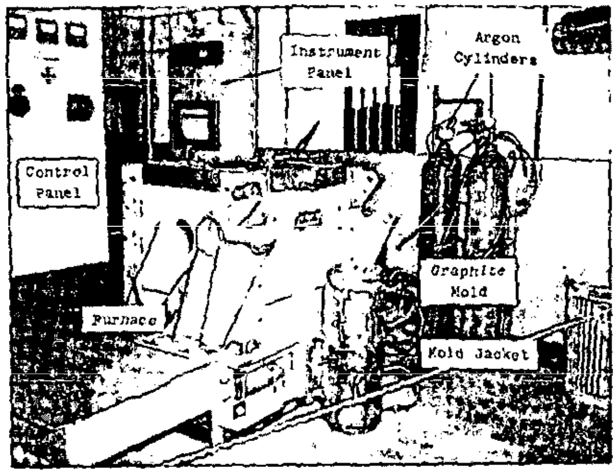

Figure 1. Scrap Recovery Furnace

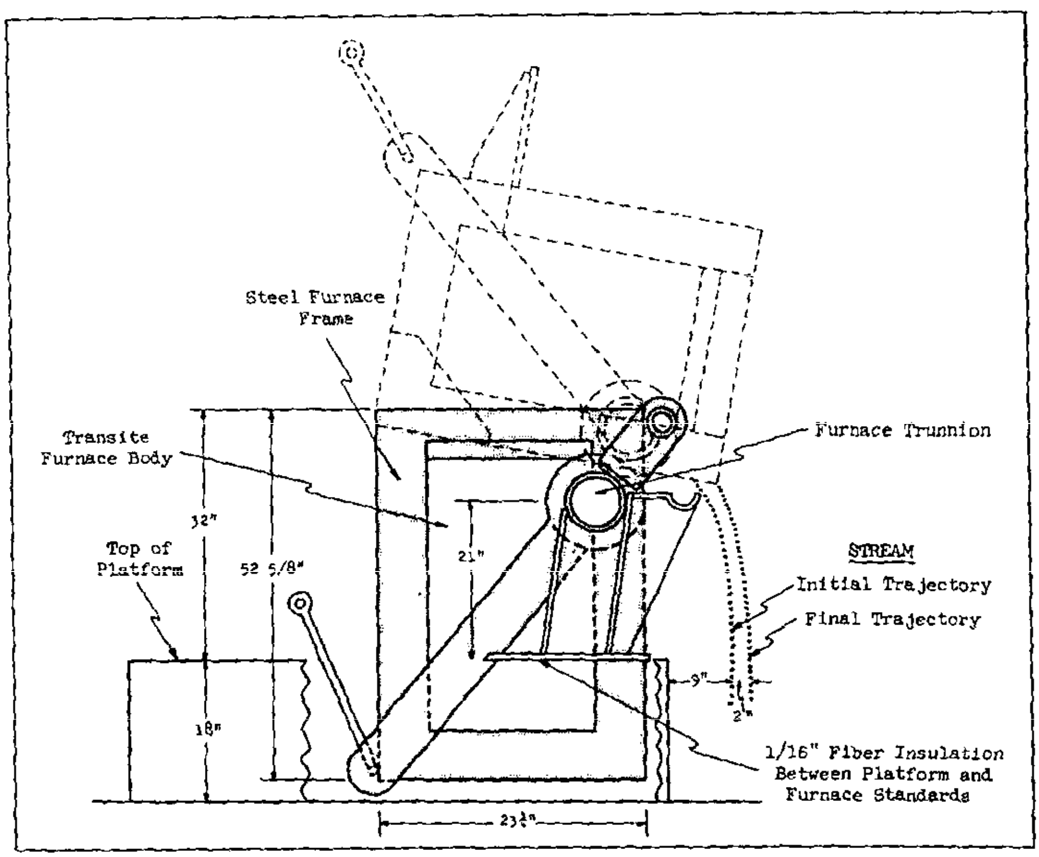

Figure 2. Side View of 100 kw Air-Melt Furnace Showing Pouring Arrangement

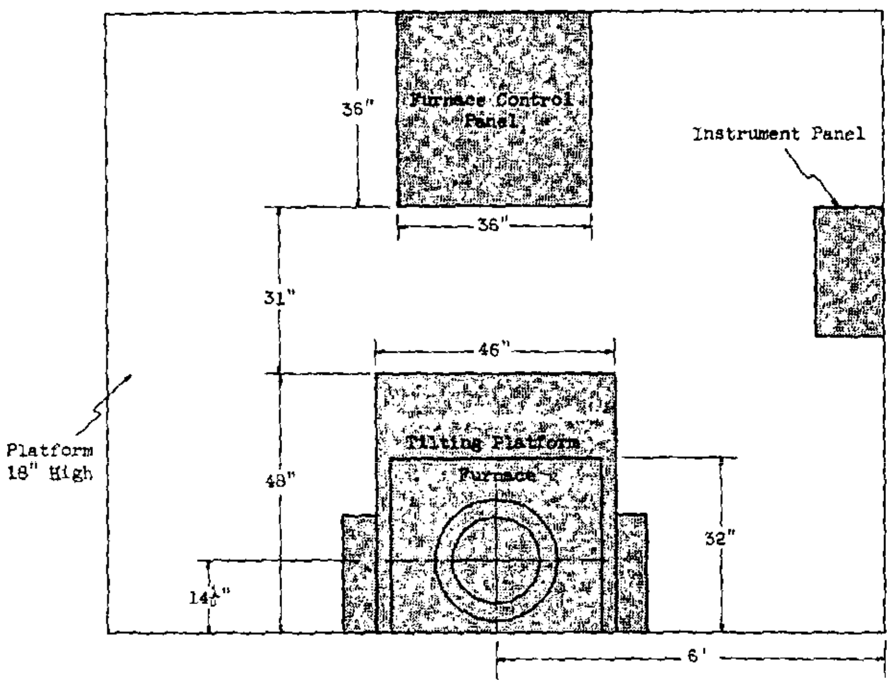

Figure 3. Plan View of Furnace Platform

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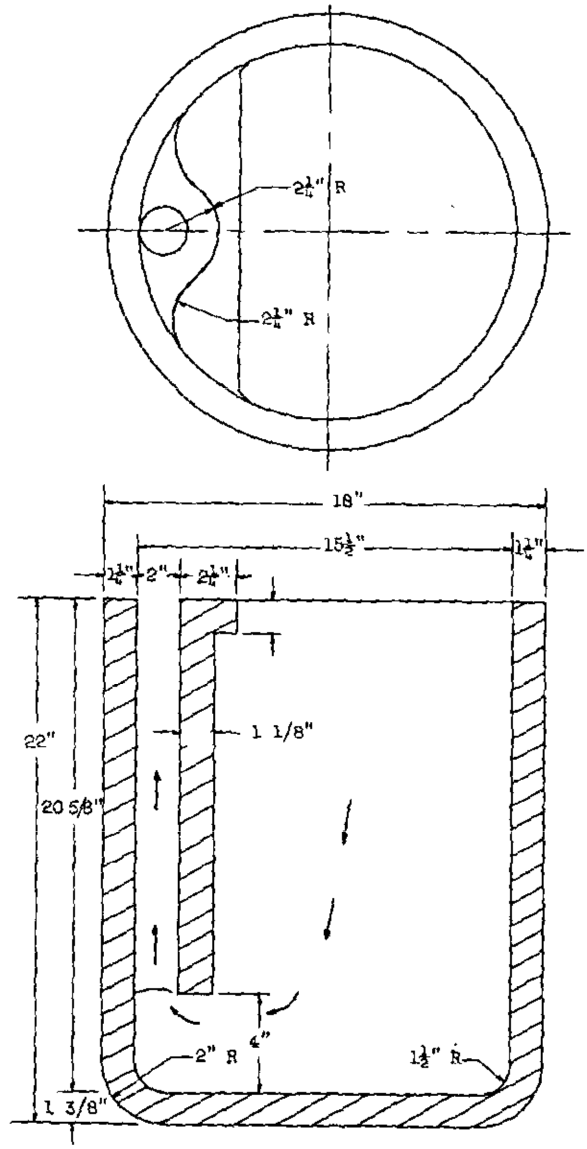

Figure 4. Bottom-Pour Crucible

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