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FURNACE DROSS - ITS FORMATION AND RECOVERY

Clarence J. Moser

Alumax Inc.
San Mateo, California

This discussion is chiefly concerned with the formation of dross and its subsequent treatment.

I feel that no matter how sophisticated we become in handling of drosses, we cannot lose sight of the fact that if the dross was not generated to begin with, later processing would not be required. As ingot, scrap and/or other aluminum-bearing materials are charged into the furnace, a number of factors affect the dross that is generated. First of all, moisture and organic compounds contribute heavily to oxide generation from both a chemical and a mechanical standpoint. Material that vaporizes when coming in contact with molten metal has a tendency to prevent the charge from going under the bath and the vapors also react with the molten aluminum. Holding time and furnace temperature are important factors in the formation of dross and good furnace scheduling is necessary to keep these factors at a minimum. The depth of the dross layer covering the molten metal is also extremely important. Figure 1 illustrates this fact.

The molten aluminum is essentially heated through radiation from the brickwork above the bath line and the luminous burner flame. The amount of heat penetrating this dross layer is directly proportional to its thickness.

Removal of this dross from the furnace is an extremely hot and dirty job and should be one of the primary concerns of the furnace designers.

Figure 2 illustrates the manual pulling of the dross onto a sloping hearth where it remains for a short period of time to allow the metallics to drain back into the furnace. It is then removed from the furnace in a manner that stops thermiting as quickly as possible. This is done by raking onto a heavy steel plate in the floor, raking into a heavy steel container or directly into a water cooled device as shown in Figure 3.

This device contains an Ajax water cooled shaking table and a rotating dross breaker. Normally, dross is carried from the furnace in an insulated container to a unit of this type. The system in the photograph, however, has an added advantage of stopping the thermiting action immediately as the dross is withdrawn and also controls the dust associated with drossing a furnace. Normally, 5%-10% of the dross weight is removed as dust through the ductwork and captured in a baghouse as shown in Figure 4 and Figure 5.

I hesitate to discuss dross analysis, since it varies so greatly and is dependent upon so many factors. However, a lot of work has been done in this regard, and in order to allow for some material balances, the drosses generated at this particular plant have a typical analysis as shown in Table I.

Table I. Typical Alumax Dross Analysis

Aluminum Oxides	25 to 30%
Metallics	65 to 75%
Mag. Oxide - Mag. Chloride	1.5 to 4%
Aluminum Carbide	2 to 3%
Aluminum Nitride	3 to 5%
Iron Oxides	.5 to 2%
Silicon Oxides	.5 to 1.5%

Factors affecting dross analysis have been and still are under investigation. It appears the metallic and oxide content are proportional to the care given in removal of the dross, and the time involved between furnace removal and cooling. The magnesium, iron, silicon, etc., are of course related to the alloy from which the dross was pulled. The relationship of the aluminum carbides and aluminum nitrides is not so easily pinned down. It is my observation that the nitride formation is a high temperature reaction, closely related to thermiting during and after furnace removal. Carbides can be formed in the furnace as a result of a chemical reaction between metallic aluminum and the products of combustion. This conclusion is drawn from an analysis of dross removed from electric furnaces, molten metal transfer pots, etc., consistently showing an aluminum carbide content of less than .5%.

Surprisingly, the dust (-100 mesh) removed from the dross contains about 20% metallic, and since no conventional fluxes are used in our melting operation, this material is salable. The high content of this dust can only be the result of rapid cooling as the dross is pulled from the furnace.

The cold dross is then charged through a vibratory feeder into the rotary barrel with a closely measured amount of salt (Figure 6).

This salt is normally 45%-55% KCl/NaCl mixture. However, in one plant we are now successfully using a 95% KCl - 5% CaCl mixture. The amount of salt charged is usually 1-1.25#/lb. of oxide charged. Typically a 1,000# charge of dross will contain 700# of metal and 300# of oxides and will require 300-400# salt addition.

Metal is tapped through an opening in the side of the barrel. See Figure 7.

The orifice in the tap hole is sized so when the metal is drained from the furnace, the molten salt, having a higher freezing temperature, immediately freezes. The barrel is then rotated, the tap hole is reamed, restuffed, and the salt residue dumped. (See Figure 8).

The salt is dumped onto a water cooled vibratory conveyor and carried through a tumbler producing what we call salt chips. The chip size produced is readily handled in further processing and prevents the need of crushing and/or grinding equipment. (Figure 9 and Figure 10.)

Analytically, the salt residue or chip is typical of that shown in Table II.

Table II. Typical Salt Residue Analysis

Metallics	8 to 15%
Metal Oxides & other Insolubles	35 to 40%
Salt	45 to 55%

Until recenly our process ended here with the salt residue being hauled away from our plant. In November our recycling facility came on stream and is now in operation. The salt chips from the rotary barrel are dumped through a grizzly and conveyed into a digester as shown in Figure 11.

Hot water is added and solution of the chips occurs quite rapidly in the rotating drum. Hot water is added not only to increase solution rates, but more importantly to hasten the conversion of aluminum carbides and nitrides to aluminum oxide. The liberated methane and ammonia gases are evacuated from the digester by the combustion air blower on the burner of the metallic concentrate dryer unit.

The digester is discharged through a rotary screen (Figure 12) removing the over-size material containing the metallic concentrates. The mesh size of this screen is dependent upon the desired aluminum content of the final recovered oxides. The concentrated brine, with the oxide fines, passes through the screen and on to a traveling belt filter (Figure 13).

This type of filter was selected not only for its ability to separate the insoluble material, but also to allow for washing the salt brine from the oxides. From the filter is discharged wash water, concentrated brine and washed oxide fines. The wash water is returned for make up in the digester; the oxide fines to a storage bin; and the concentrated brine is pumped to the evaporator. (See Figure 14.)

This rotary evaporator is presently fired by an oil burner, but as quickly as process variables become "nailed down" , we plan to utilize waste heat from a nearby melting furnace. It is planned on future installations to utilize the waste heat from the rotary salt barrel. This unit is presently operating at about 80% thermal efficiency and hopefully with some modification we can attain a 90% level. The salt crystals are continuously removed from a recirculating brine system with a centrifugal filter and are discharged with a moisture content of approximately 10%.

The recycled salt is suitable for charging directly back into the rotary barrels (Figure 15).

The oxides produced by this process are relatively salt free and are suitable for use in several industries. If the screen cut is made at 24 mesh, they have an analysis typically as shown in Table III.

Table III. Typical Oxide Analysis

Metallics	18 to 20%
Hydrated Aluminum Oxide	65 to 75%
Magnesium Oxide	1.5 to 4%
Iron Oxide	1.0 to 2.5%
Silicon Oxide	1.5 to 3%
Aluminum Carbide	.05%
Aluminum Nitride	.20 to 0.4%
Salt	0.5%

If the screen cut were made at 64 mesh, the metallic content would drop approximately 10%. This material is now being sold and contributes sizably to the economics of this process.

In review, a typical process flow sheet is presented in Figure 16 and Figure 17.

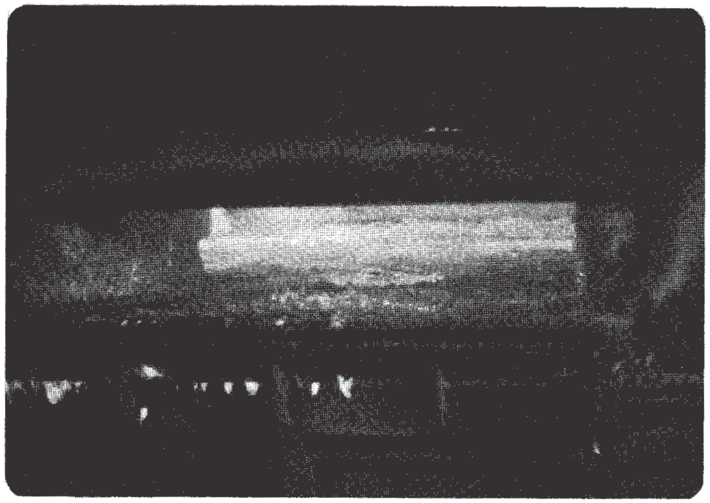

Figure 1 - Dross Layer on Molten Aluminum

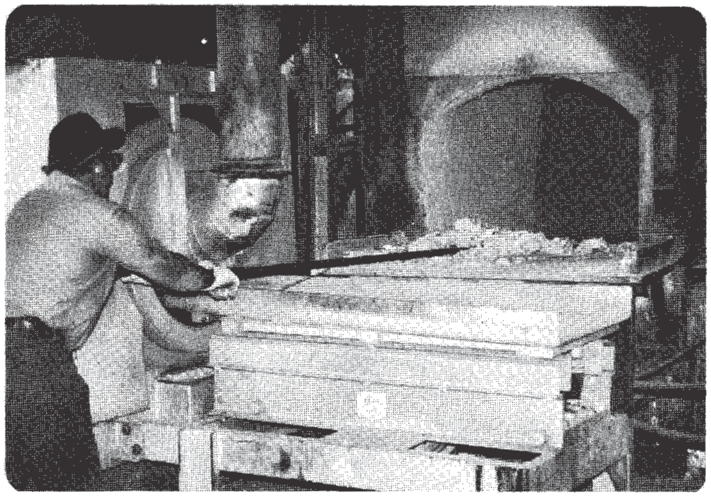

Figure 2 - Pulling Dross Manually

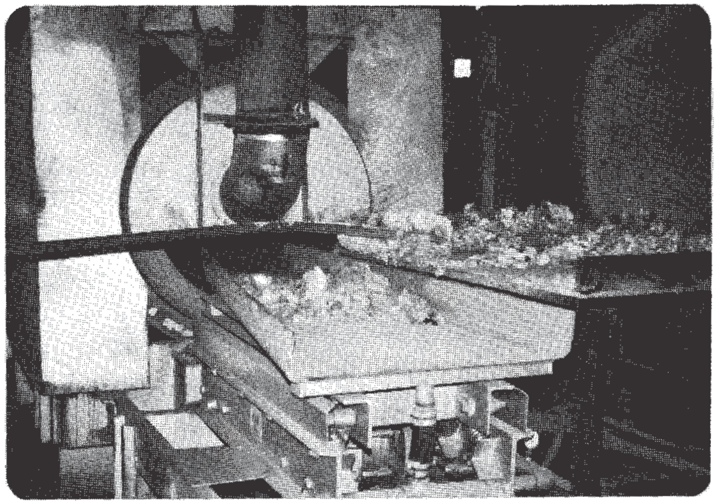

Figure 3 - Dross Cooler - Charging

Figure 4 - Dross Cooler Dust Collection System

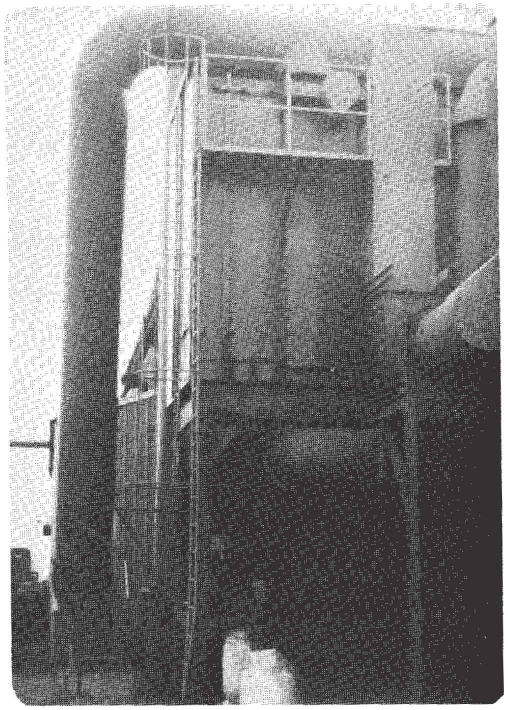

Figure 5 - Dross Cooler Baghouse

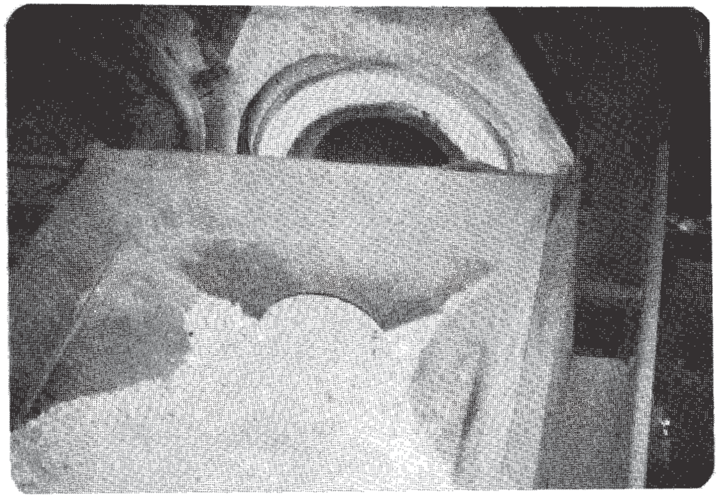

Figure 6 - Charging the Rotary Salt Barrel

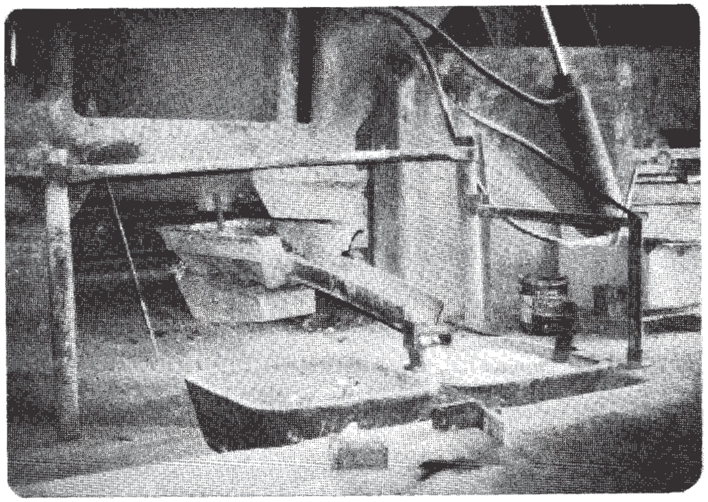

Figure 7 - Tapping Metal from Rotary Barrel

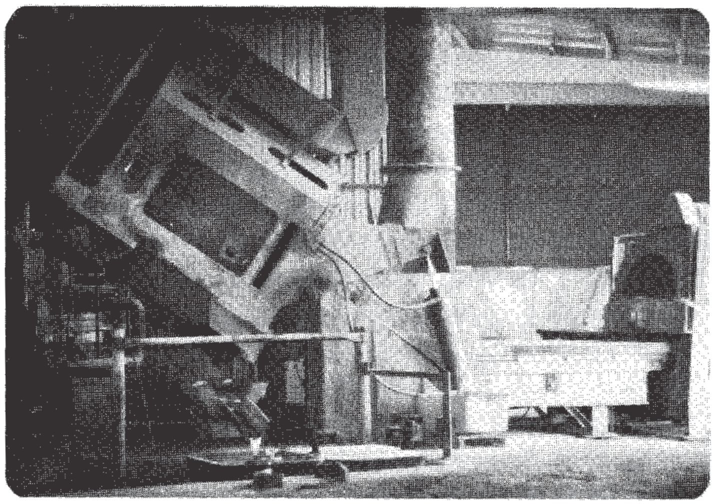

Figure 8 - Emptying Salt Slag from a Rotary Barrel

Figure 9 - Salt Slag Cooler

Figure 10 - Salt Chips

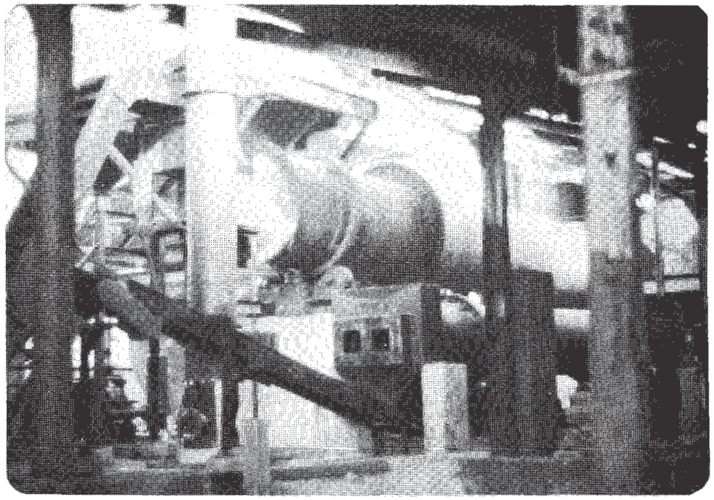

Figure 11 - Salt Chip Digestor

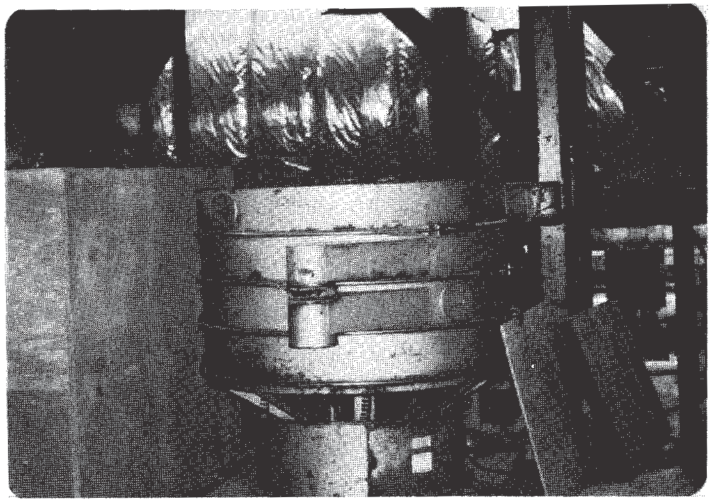

Figure 12 - Wet Rotary Screen Separating Aluminum Concentrates from Oxide Fines

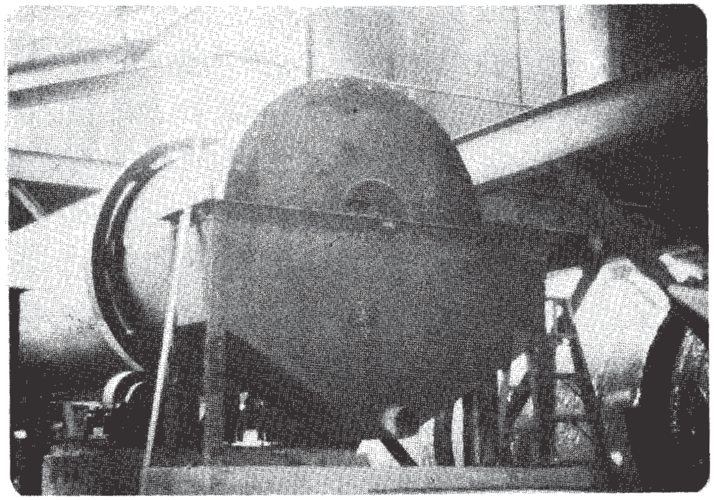

Figure 14 - Salt Brine Kiln Evaporator-Discharge End

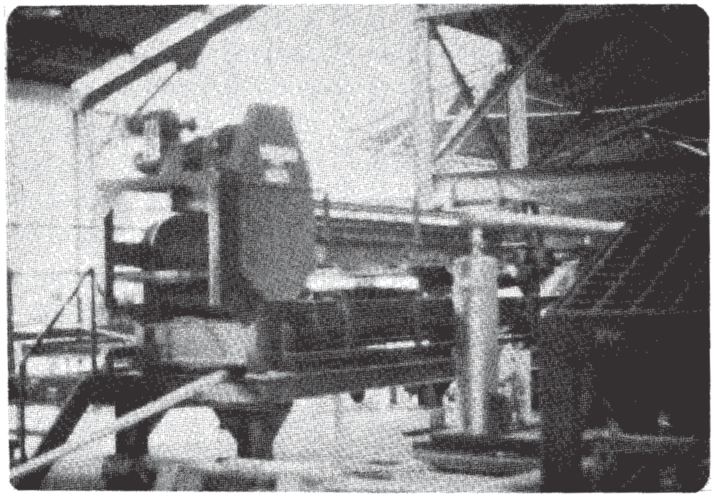

Figure 13 - Traveling Belt Filter for Removal of Oxide Fines

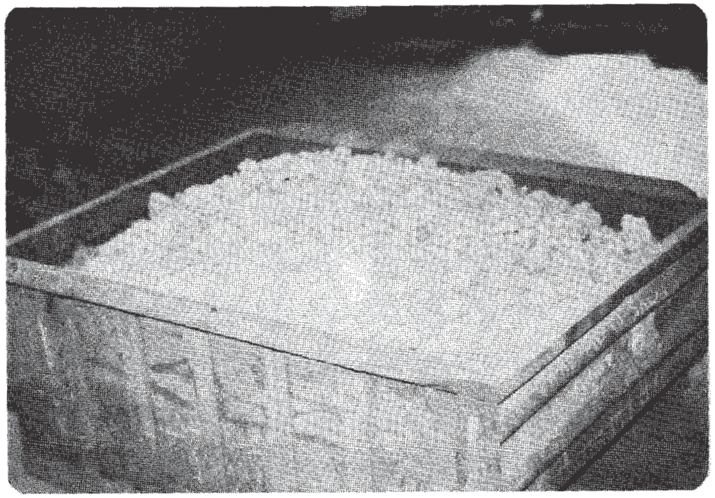

Figure 15 - Recycled Salt

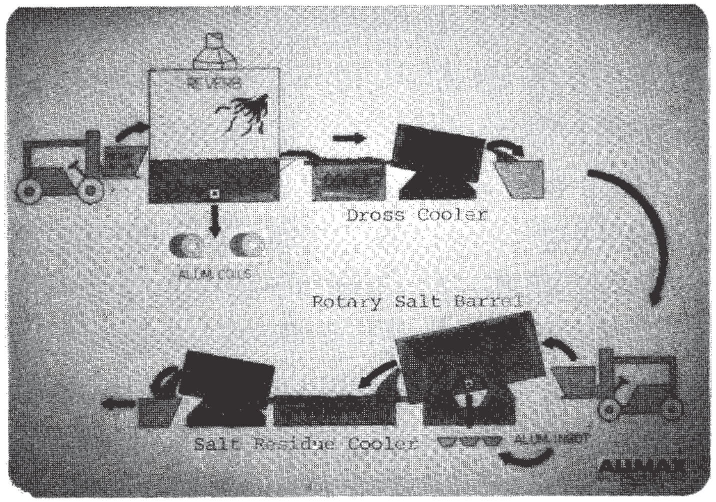

Figure 16 - Process Flow Sheet - Furnace thru Rotary Salt Barrel

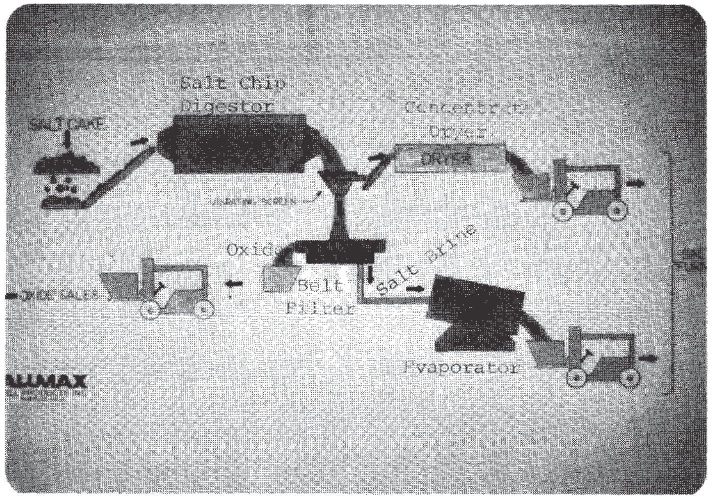

Figure 17 - Process Flow Sheet - Salt Recovery and Recycling