

Electromagnetic Stirring for Aluminum Melting

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THE CHALLENGE:

Improving Productivity and Reducing Dross Production at Reynolds Metals Company

Background

The primary aluminum industry relies on bauxite as its primary source of aluminum. However, today there is an increasing trend toward remelting aluminum scrap rather than obtaining aluminum from the reduction of bauxite. This results in significant energy savings as it requires 25 times as much electrical energy to produce aluminum from bauxite compared to simply remelting scrap. Scrap available for remelting ranges from "home" (in-house) scrap, "new" (prompt industrial) scrap to "old or obsolete" (post consumer) scrap. Also, sizable quantities of aluminum ingot are also being melted.

The majority of smelting of aluminum takes place in reverberatory furnaces and, in the case of small operations, in rotary furnaces. Most reverberatory furnaces are fired by natural gas or oil; however, there are electric radiant energy furnaces in use. The reverberatory furnace ranges in capacity from 15 to 100 tons. In this type of furnace, raw materials (ingot, scrap, and molten metal) are usually introduced into a charging well containing molten metal at one end of the furnace. The smelting or melting operation can consist of several steps depending upon the product to be produced. These steps include 1) charging the raw material; 2) adding fluxing agents to retard oxidation; 3) adding alloying agents; 4) mixing; 5) demagging to remove magnesium; 6) skimming dross or oxide; and 7) degassing.

Mixing is one of the more important operations and is performed almost continuously in the reverberatory furnace. Its purpose is to ensure uniform composition and to immerse light scrap into the melt to reduce oxidation. It generally is accomplished by injecting nitrogen gas or by use of mechanical means such as rakes and impeller pumps.

Electromagnetic stirrers have been in operation in the aluminum industry for several years but their incorporation into melter operations has been slow to develop. The first installation of electromagnetic stirring on a reverberatory melter for aluminum scrap was made in 1968 at Kaiser Aluminum, Trentwood, Washington. However, very little has been reported about the results and benefits to be obtained by this technology.

Reynolds EMS Installation

Recognizing the potential benefits to be gained from electromagnetic stirring, Reynolds Metals Company equipped one of the melters at their new casthouse facility in Muscle Shoals, Alabama with an ABB Induction Stirring unit. The ABB

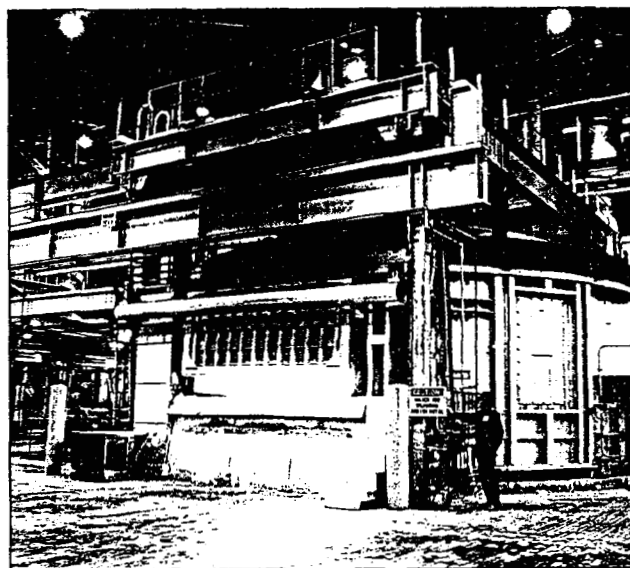


Figure 1. Reynolds Metals Company's aluminum melting furnace with electromagnetic stirring.

ElectroMagnetic Stirrer (EMS) is water cooled and is mounted under the furnace bottom and has no contact with the furnace, see Figure 1. The furnace bottom plate, in front of the stirrer, is made of nonmagnetic material, normally stainless steel, to allow the magnetic field to penetrate into the melt. The linear motor inductor installed under the furnace bottom provides a low-frequency, moving magnetic field. This, in turn, causes an induction current to flow which acts with the magnetic field or flux to induce an electromagnetic force or thrust in the molten aluminum. As a result, a stirring action takes place in the molten bath.

Evaluation of EMS

The EMS was installed at the Reynolds Plant in mid-year 1991 and shortly thereafter a study was initiated by the plant to determine the effect of electromagnetic stirring on dross generation and melting rates. Mr. Antonio F. Saavedra of Reynolds was responsible for the evaluation and the information reported in this TechApplication is the work of Mr. Saavedra. For this study, two furnaces processing 3104 aluminum can stock alloy were chosen, one with the EMS (Melter A) and the other without the EMS (Melter B). The charge to the furnaces consisted of solid aluminum (scrap) and molten aluminum from primary production. In the melting operation the elapsed time between charging the furnace and transferring the molten metal to the holding furnace is referred to in casthouse terminology as a "drop" but in this case the term "cycle" will be used. The total cycle time was the interval between initial charge to the furnace and the moment when the metal was transferred to the holding furnace. Another criteria used in the study was "melting time" which was the elapsed time between initial charging to the furnace and the time at which the bath thermocouple was inserted into the molten bath signaling a uniform melt temperature and the completion of melting.

Melting of aluminum results in the formation of aluminum oxide or "dross" on the surface of the molten bath. The dross can entrap aluminum droplets and consequently increase metal loss and decrease yield. In order to compare the effect of EMS on dross generation, the dross was skimmed from the melter furnaces into preweighed cast iron pots and the weight of dross determined.

Results of EMS Evaluation

A total of 14 cycles was observed for Melter A and 17 cycles for Melter B. In the majority of the cycles considerably more solid aluminum than molten feed was charged into both melters, the average ratio being approximately 3/1. There were very few instances in which a mostly molten charge was used. The results of the study showed that the average cycle time for Melter B, without EMS, was 50% longer than for Melter A, with EMS, during the evaluation period. Also, it took 75% more time to complete the melting phase in the furnace without EMS compared to the furnace with EMS.

Melting times as a function of the melting rates is shown in Figure 2. It is evident that the furnace with EMS achieved higher melt rates for comparable charge weights. Further, Melter A had melting rates ranging from 15 tons/hr to nearly 40 tons/hr resulting in melting times ranging from 2 to 5 hours. Melter B melt rates ranged from 10 to 20 tons/hr resulting in melting times ranging from 4 to 8 hours. It is interesting to note that the benefits of EMS are not obtained if the melt rates are low and consequently have long melting times.

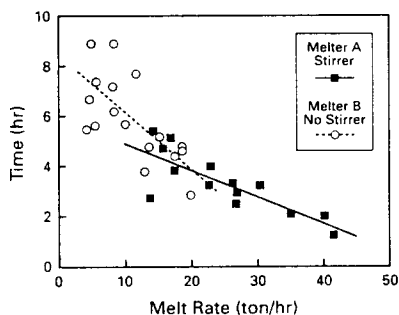


Figure 2. Comparison of Melting Rates and Resulting Melting Times. Courtesy of Reynolds Metals Company

With the shorter melting times for Melter A, the total cycle time or process time was also shorter as a result of EMS and thus Melter A had greater productivity than Melter B. The melt rates for Melter A ranged approximately from 15 to 40 tons/hr resulting in process rates of 15 to 30 tons/hr. By comparison melter B rates ranged from about 5 tons/hr to 20 tons/hr yielding process rates that ranged from 3 to 12 tons/hr.

The data developed on dross production showed that Melter A with EMS generally produced about 37% less dross than Melter B without the EMS.

Benefits of EMS

The following benefits were realized by Reynolds Metals on comparing melters with and without electromagnetic stirring. They include:

- Melt times are shorter for furnaces equipped with electromagnetic stirrers.
- Melters equipped with EMS achieve significantly higher melt rates resulting in increased productivity.
- Dross production is significantly lower for melters with EMS.

COMPANY PROFILE

Reynolds Metals Company is a fully integrated global manufacturer, distributor, and marketer of value-added aluminum products. Reynolds (the World's third largest aluminum company) is engaged in bauxite mining, alumina refining, and the production of primary and reclaimed aluminum. The company produces calcined petroleum coke and carbon anodes used in aluminum smelting. Reynolds also produces a broad range of plastic products.

Principal fabricated products include flexible packaging materials, products for the foodservice market. Reynolds brand and private-label consumer products for home food management including Reynolds Wrap, beverage cans, aircraft and automotive components, building and constructive materials, sheet and plate, extruded aluminum shapes, aluminum-based powders, pastes, and chemicals.

The company began operations 75 years ago in Louisville, Ky., as the U.S. Foil Company. Today, Reynolds and its affiliates operate more than 100 manufacturing facilities and 24 service centers in 22 nations. The company employs approximately 29,000 people.

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