Summary

The paper presents a new reactor concept for carbothermic reduction of aluminum and an ongoing test program for experimental verification of the concept. The development program is an Alcoa/Elkem effort based upon an initiative from Alcoa to reconsider carbothermic reduction of aluminum as an alternative to the Hall-Heroult process. The incentive is to maintain growth and competitiveness for the aluminum industry, since the US industry-wide initiative, “Aluminum Industry Technology Roadmap”, has identified the need for a significant reduction in capital- and operating costs for primary aluminum production to maintain the competitiveness relative to steel and plastics.

In-house knowledge about the Aluminum-Oxygen-Carbon-system and some of the latest developments in Elkem’s proprietary reactor technology, was the basis for Elkem to suggest an Advanced Reactor Processing Concept (ARP) for carbothermic aluminum production. The experiences of Reynolds, Pechiney and Alcan related to their work on Aluminum Carbothermic Technology (ACT), to the extent known, have also taken into consideration when the concept was developed.

The resulting multi-stage reactor, tailor-made to process requirements, is based on slag resistance smelting and employs the latest high intensity smelting technology.
Introduction

The purpose of this presentation is to describe a new processing system for carbothermic production
of aluminum. The design basis for the reactor system is Alcoa’s fundamental understanding of the
process and Elkem’s experience in designing tailor-made electric reactors to meet process
requirements. The resulting basic reactor concept is based on utilizing proven modules from
Elkem’s inventory of reactor technology hardware. The resulting integrated processing system,
named the “Advanced Reactor Process”, has been found promising enough to jointly pursue
through an ambitious laboratory/pilot scale test program.

Throughout its history, the aluminum industry has relied on the Hall-Heroult process for aluminum
smelting. This process is energy-intensive and costly, compared to processes used to produce such
competing materials as steel and plastics. In order to maintain existing markets and to develop new
market opportunities for aluminum in such industries as automotive, packaging and building/
construction, it is imperative that the aluminum industry reduce primary aluminum production
costs. Carbothermic technology has the potential to revolutionize the aluminum smelting process.

Alcoa and Elkem believe that the Advanced Reactor Process (ARP) would decrease the cost of
producing primary aluminum by at least 25 percent and would reduce capital costs approximately
30 percent, compared to electrolytic plant costs.

Commercializing ARP would improve smelting performance, which would allow for higher
productivity to meet increased demand as necessary. It is currently estimated that the production
rate of an ARP reactor would be around 100 times greater than the largest Hall cell. Looking at a
400,000 metric ton smelting plant, the Hall-Heroult process requires 600 Hall cells to maintain the
production rate. In contrast, the same capacity ARP plant would require five reactors to generate the
same output. In addition, the carbothermic process increases energy efficiency by lowering the
electric power required to drive the process (9,500 kWh/MT, versus 13,640 kWh/MT for Hall). This
increased efficiency not only has economic benefits, but offers direct environmental benefits as
well, because it reduces the power needed. As a result, CO2 emissions can be reduced at the power
generation site. Finally, ARP has the potential for reducing labor costs because of the much smaller
number of production units required for the same production volume.

Historical Review

Our proposed research is predicated upon the promising results of work done by Reynolds between
1971 and 1984 to develop an electric arc dual furnace concept using petroleum coke to reduce
Bayer alumina to aluminum. Their work included a novel approach to decrease the carbon content
of the aluminum product. Since 1984, more fundamental thermodynamic data has become
available and electric reduction furnace technology has improved, making carbothermic aluminum a
technology that needs revisiting.

Reynolds demonstrated three phases of operation per metal tap cycle independently: a slag pool
building stage with electrodes in a submerged slag resistance mode; metal making, with the
electrodes pulled out of the slag and operating in an open arc mode; and decarbonization of the
tapped product through alumina extraction of the carbide from the metal-carbide phase.

- A 100 kW dc unit was operated in week-long campaigns with taps once per day.
- A 200 kW ac, twin-electrode unit was operated in 10- to 12-day campaigns with two taps
  per day.

Reynolds terminated the project in 1984, primarily because of the company's economic status and
the downside trend being experienced by the aluminum industry.
Pechiney conducted research and development on electric arc furnace direct reduction from 1955 until 1967. At Grenoble in France, Pechiney operated furnaces ranging from 150 kW single-phase dc to 2.7 MW, 3-phase ac over a five-year period, and produced carbide-saturated metal containing 60% aluminum. Their operations moved to Nogueres in 1960. Over the next seven years, Pechiney ran:

1. A single-phase dc submerged arc at up to 6 MW, producing 300 tons of carbide-saturated metal, and
2. A 2 MW, three-phase ac open arc, producing about 540 tons of 70-80% aluminum.

Pechiney terminated the program in 1967 because they considered the cost to commercialize the process too high to justify replacing the existing Hall-Heroult electrolytic process. The estimate was based on results from the pilot furnace operations, which suffered from high consumption of aluminum and carbon, high vaporization losses and high energy usage (18,750 kWh/metric ton).

The development efforts of Reynolds and Pechiney had as the starting point the submerged arc electric furnace for silicon production as a common denominator. This caused problems with vaporization of aluminum due to the high temperatures close to the arc and made a charge column over the arc an absolute requirement. The charge column, like for the silicon process, intended to supply feed to the reactor, recover the vapor losses and utilize the heat from the reaction gases. The operation of the charge column, however, could not be controlled and stabilized the way it is in the silicon process, due to the formation of liquid phases in the column.

Alcan also put considerable effort into the study of carbothermic reduction of alumina based on electric reduction furnace technology. Alcan based their reactor on slag resistance heating instead of submerged arc smelting technology. To further reduce the vapour losses and the resulting high consumption figures the pre-reduction and metal making steps were conducted in two separate chambers.

About two-thirds of the carbon monoxide generated in the total process occur during pre-reduction of alumina to aluminum carbide. By keeping this high flow of carbon monoxide away from the metal producing stage, they were able to minimize the impact of sweep gas on volatile species. Slag was recycled between the two chambers and metal phase was tapped from the second, higher temperature zone.

It is believed that the project was terminated because the company could not cost effectively resolve basic reactor engineering problems such as current paths between electrodes and liquid melt transfers.

**Thermodynamic background**

The carbothermic production of aluminum shall realize the ideal reaction

\[
\text{Al}_2\text{O}_3 + 3 \text{C} = 2 \text{Al} + 3 \text{CO} \quad (1)
\]

The Gibbs energy of this reaction indicates that it can run at high temperatures. However, if we try to heat a mixture of \( \text{Al}_2\text{O}_3 \) and \( \text{C} \) other reactions are preferred, and we get a rather complex product. At a temperature of about 1950 °C \( \text{Al}_4\text{C}_3 \) is formed, and it makes a melt with \( \text{Al}_2\text{O}_3 \):

\[
\text{Al}_2\text{O}_3 + \text{C} \rightarrow [\text{Al}_4\text{C}_3 - \text{Al}_2\text{O}_3](\text{slag}) + [\text{CO}-\text{Al}_2\text{O}-\text{Al}](\text{g}) \quad (2)
\]

The reduction gives as expected \( \text{CO} \), but in addition there are significant amounts of other gas species: \( \text{Al}_2\text{O} \) and \( \text{Al} \).
With further heating to about 2050 °C Al₂O₃ and Al₄C₃ in the slag react and give a C-containing alloy:

\[
[\text{Al}_2\text{O}_3 - \text{Al}_4\text{C}_3] \text{(slag)} \rightarrow [\text{Al-C}] \text{(alloy)} + [\text{CO-Al}_2\text{O-Al}] \text{(g)} \quad (3)
\]

The content of the gases Al₂O(g) and Al(g) is considerably higher in reaction (3) than in reaction (2).

The rather complex chemistry of the process is well summarized by an operating diagram developed at ALCOA (Roha, D. (1998)) and shown in Figure 1. It applies to reaction at atmospheric pressure.

The phase diagram of the slag Al₂O₃ - Al₄C₃ is shown in black. The conditions for reaction between Al₂O₃ and C are indicated as the Prereduction line. We assume that we heat a mixture with a low C.

At first the temperature rises. At a temperature around 1950 °C, a melt of the composition of point 1 is formed, and the slag will have an excess of solid Al₂O₃. With increasing addition of C, the excess of solid Al₂O₃ decreases, and the temperature is constant since all the heat addition is consumed by the reaction between Al₂O₃ and C. At point 1 the Al₂O₃ is consumed and the slag is completely molten. With further heating and addition of C, the reaction temperature rises, while the composition of the slag moves to higher Al₄C₃ content. At point 2 the slag is saturated and solid Al₄C₃ precipitates. With further heating and C addition more Al₄C₃ is produced, while the composition of the melt and the temperature are constant.

If we continue heating, the temperature rises until it reaches the reduction line at about 2050 °C. Then Al₂O₃ and Al₄C₃ react and give a C-containing Al alloy. If the slag is saturated with C, as indicated by point 3, the alloy corresponds to 30 weight% Al₄C₃ and 70 weight% Al. The temperature and the composition of the phases are constant until any solid Al₄C₃ is consumed, and then the dissolved Al₄C₃ reacts. The reaction changes the composition of the slag to the left along the reduction line. The temperature rises, and the content of C in the alloy decreases. The content of Al₂O(g) and Al(g) in the gas increases, which gives higher Al losses in the gas phase. When the Al₄C₃ content of the slag has fallen to about 17 mol per cent, the reaction gives only gas and no alloy.

This diagram gives a good qualitative picture of the high temperature equilibrium of the Al-producing system. However, the experimental foundation is rather incomplete, and the numerical values are uncertain. The diagram is a good base for the determination of a strategy for the development of the process, but the experimenter must be prepared for quantitative deviations from the expectations.
If we establish a C-saturated slag $\text{Al}_2\text{O}_3$-$\text{Al}_4\text{C}_3$, it will give an alloy Al-C with about 30 weight% $\text{Al}_4\text{C}_3$. To have as low gas loss as possible, we must sustain the C-saturation of the slag to avoid moving leftwards along the reduction line. In principle we can sustain the slag composition by adding charge mixtures $[\text{Al}_2\text{O}_3 + x \text{C}]$ or $[\text{Al}_2\text{O}_3 + x \text{Al}_4\text{C}_3]$. If we add an even flow of charge with C, we will have the two steps running simultaneously in the furnace. The temperature will be either on the Reduction line or above it, resulting in high vapor pressures for Al and Al2O. However, to keep the Al-production high, the temperature must be high, and the reaction between $\text{Al}_2\text{O}_3$ and alloy will tend to enrich the gas with Al-containing species even when the presence of free C locally can give gas with lower Al content. Therefore we will expect that the mean gas composition for a melt sustained with C will be close to the composition of a melt sustained with $\text{Al}_4\text{C}_3$. We will illustrate the importance of this with an example.

We assume that we run the reaction at the equilibrium for alloy production with solid $\text{Al}_4\text{C}_3$ present. Then we have according to the Alcoa diagram:

- 30 weight % C in alloy
- Al loss: 16.6 %

This loss can result from a gas composition:

- $p_{\text{Al}_2\text{O}_3} = 0.152$ bar
- $p_{\text{Al}} = 0.061$ bar

If we sustain the bath by adding $\text{Al}_2\text{O}_3$ and $\text{Al}_4\text{C}_3$, the overall reaction becomes:

$$\text{Al}_2\text{O}_3 + 1.19 \text{Al}_4\text{C}_3 = [5.62 \text{ Al} + 1.03 \text{ C}](\text{alloy}) + [0.48 \text{ Al}_2\text{O}_3 + 0.19 \text{ Al} + 2.52 \text{ CO}](\text{gas})$$

The Al loss is:
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Al loss = 16.4%
If we use C as reductant, the reaction becomes:

\[
\text{Al}_2\text{O}_3 + 2.70 \text{ C} = [0.88 \text{ Al} + 0.16 \text{ C}]\text{(alloy)} + [0.46 \text{ Al}_2\text{O} + 0.21 \text{ Al} + 2.54 \text{ CO}]\text{(gas)}
\]

and the Al loss increases strongly:

\[
\text{Al loss} = 56.0\%
\]

The amount of gas is the same for both reactions, since the entire O added must leave the reaction as gas. However, the production of Al is much higher when the slag composition is sustained by \(\text{Al}_4\text{C}_3\) as reductant. The overall stoichiometry of the process set restrictions on the amount of recovery charge that can be added through the recovery column, and thus of the gas that can be treated. Therefore it is important to have a high alloy production per unit of gas.

The gas out from step 2 contains heat and aluminum at an energy-rich state. It is essential for the economy of the process to recover as much as possible of the heat and the aluminum. We assume that we send the gas through a column filled with a recovery charge.

Hot gas from step 2 cools when it meets cold recovery charge and several reactions may occur. The Al-containing species may simply condense

\[
\text{Al}_2\text{O}(g) = \text{Al}_2\text{O} \text{(unstable condensate)} = \frac{1}{3} \cdot [\text{Al}_2\text{O}_3 + 4 \text{ Al}]
\]

\[
\text{Al}(g) = \text{Al}(l)
\]

or they may react with CO:

\[
9 \text{Al}_2\text{O}(g) + 6 \text{CO}(g) = 2 \text{Al}_4\text{C}_3 + 5 \text{Al}_2\text{O}_3
\]

\[
6 \text{Al}(g) + 3 \text{CO} = \text{Al}_4\text{C}_3 + \text{Al}_2\text{O}_3
\]

Here \(\text{Al}_2\text{O}_3\) and \(\text{Al}_4\text{C}_3\) occur together, and they may give a melt if the temperature is high enough. Also the compound \(4 \text{Al}_2\text{O}_3 \cdot \text{Al}_4\text{C}_3 \text{(3 Al}_4\text{O}_4\text{C)}\) may appear.

The condensation reactions heat the recovery charge. When the C is sufficiently hot, it may react directly with the Al-containing species:

\[
2 \text{Al}_2\text{O}(g) + 5 \text{C}(s) = \text{Al}_4\text{C}_3(s) + 2 \text{CO}
\]

\[
4 \text{Al}(g) + 3 \text{C}(s) = \text{Al}_4\text{C}_3
\]

These reactions go to the right, as long as the temperature is lower than the stability limit of \(\text{Al}_4\text{C}_3\), but some heating is necessary to obtain a sufficient rate. The problems in gas recovery will be illustrated by an example where the gas from the example above is led through a recovery charge of C.

We assume that the gas from step 2 has the composition: 15.2 % \(\text{Al}_2\text{O}\), 6.1 % Al, 78.7 % CO. This gas is sent in countercurrent with the recovery charge that consists of C. The flow of recovery charge is balanced to give exactly enough C to consume all the Al-containing gas:

\[
0.152 \text{Al}_2\text{O}(g) + 0.050 \text{Al}(g) + 0.418 \text{ C} = 0.089 \text{Al}_4\text{C}_3 + 0.950 \text{ CO}
\]

The recovery charge enters the recovery column at room temperature 25 °C, and the gas from the step 2 has the temperature 2100 °C of the reaction. The \(\text{Al}_4\text{C}_3\) from the recovery column is heated to the same temperature. An adiabatic heat balance for the recovery column then shows that the
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purified gas must have a temperature 2322 °C. There is therefore excess heat which will be lost through the column sidewalls and/or used for energy recovery. The recovery process is not well understood. The main property of the column is its ability to recover Al and heat, but for the operation of a column the flow properties and the gas permeability of the charge is essential. A first aim is to simulate the reaction physically by conducting furnace gas through a layer of C, and observing the product. The knowledge of the reactions in the carbothermic aluminum process is incomplete. The phase diagram Al₂O₃ - Al₄C₃ is rather uncertain, and the activities and the enthalpy of mixing in melts Al₂O₃ - Al₄C₃ are unknown. Knowledge of these properties is important for quantitative calculations and modeling of the process. However, the available knowledge gives a qualitative understanding that is a fairly good background for the construction of a reactor to realize the carbothermic aluminum reaction.

Reactor Design Challenges identified by Earlier Programs

Reviewing the experiences from earlier efforts to develop a carbothermic reduction process for aluminum and keeping in mind that the resulting reactor design must allow process optimization based on the thermodynamics of the Al-O-C system, the following major reactor design challenges were identified:

1) Continuous flow/transport of molten “product” between process steps.
2) Semi-continuous solid feed to the smelting steps, avoiding uncontrollable charge columns with respect to reactions and material flow.
3) Smelting power supply to each process step to allow accurate temperature control with a minimum of thermal gradients and no local superheats.
4) Lining concepts and cooling systems, which allow stable smelting operations above 2000 °C.
5) Gas tight, pressure controlled reactor to allow Al-vapour recovery/recycling and efficient energy recovery from an undiluted CO offgas.

Each of these design challenges had to be solved to arrive at a processing concept, which is both technically and economically viable.

The basic, in principle solutions to the above listed reactor design challenges and/or problems, were for the most part found in Elkem’s inventory of proprietary reactor technology modules. This inventory consists partly of state-of-the-art equipment and processing systems which covers the full range of traditional, electric furnace based, carbothermic reduction processes.
The other part of this inventory is a technology platform which Elkem developed in the 1980’s. This new and advanced technology was based upon Elkem’s core smelting technology with new elements like convective, hot media cooled freeze linings to eliminate refractory considerations and closed circuit, high temperature evaporation cooling to lock in the operating temperature of critical hardware at elevated temperatures.

The development of this new reactor technology, called the Multi-Purpose Furnace technology (EMPF®), was primarily aimed at treatment of solid hazardous waste materials, which often have extreme process requirements. Most of the new modules and processing systems designed, built and tested/supplied during this period were based on high intensity, slag resistance smelting. Basic reactor design concepts which incorporate the full range of new and advanced hardware will allow “Ultra High Intensity Smelting”.

**Description of the Alcoa/Elkem - concept**

The idea that tailor-making of a reactor to process requirements could be applied to carbothermic aluminum originated in Elkem Technology during general discussions with Alcoa on the applicability of modern state-of-the-art Silicon metal furnaces as a starting point for revisiting Aluminum Carbothermic Technology (ACT). It was decided to pursue this idea of trying to design a new processing concept for carbothermic aluminum based on a general reactor technology approach. Subsequent investigations and deliberations, which included all available information related to earlier work on ACT, resulted in a viable processing concept under the working name of Advanced Reactor Processing (ARP).

The ACT-ARP concept was born.

The following conceptual sketch (Figure 2) illustrates both the reactor and the process.

![Figure 2: Drawing of the ACT-ARP-concept](image-url)
The reactor is a two-compartment vessel separated by a wall that will allow an underflow between the reaction zones (Compartment 1 & 2). The energy will be introduced and controlled separately in the two compartments.

Compartment 1 can be considered a pre-reduction chamber where alumina (Al₂O₃) and carbon react at the lowest possible temperature to form an Al₂O₃ slag which is saturated with Al₄C₃ (20 – 25% Al₄C₃ is expected.). We call this stage 1 of the process. The energy input in this compartment will be based on traditional vertical electrodes and mineral wool smelting strategies to ensure temperature control and continuous homogenization of the bath.

Compartment 2 can be considered the final reduction chamber where the temperature is raised by energy input based on multiple pairs of electrodes through the sidewall so that Al₂O₃ reacts with Al₄C₃ to produce Al and CO (stage 2 of the process). Since the melt produced in compartment 1, which continuously replenishes the melt which reacts, does not contain nearly enough Al₄C₃, the deficit is made up by injection. This injection provides together with the energy input the metallurgical control of this compartment.

The aluminum produced, saturated with Al₄C₃ (20 – 35% Al₄C3) is lighter than the reacting melt and will form a layer on top. An over/under-flow weir will continuously remove the product from the compartment. A controlled cooling of the product by a combination of coolers and Al-scrap melting is foreseen to precipitate the Al₄C3 for mechanical removal and recycling to the process through the injection system in compartment 2. Remaining Al₄C₃ (1 – 2%) can then be removed by traditional filtering techniques and recycled with the filters to compartment 1.

Recycling of Al₂O and Al vapors from both compartments as well as production of the remaining Al₄C₃ required in compartment 2 will be achieved by reacting the offgases from each compartment in separate or combined coke/ Al₂O₃ filters. Each filter will be based on electric calcining reactors which allow control of both temperature and retention time for the coke/ Al₂O₃ filter material.

The in principle 100% CO offgases from both compartments are after cleaning in the filters used together with energy reclaimed from the hot-media cooling of the reactor in an energy recovery system to generate electricity for recycling to the reactor.

**Experimental Work in Progress**

Stage 1 smelting: A slag bath of basically Al₂O₃ and Al₄C₃, maintaining a level of Al₄C₃ to be determined according to the outcome from the investigation of the kinetics in the vapor recovery units, is to be produced. This will be done by charging alumina and carbon as agglomerates or as mixtures to the reactor and adjust the power input to achieve an operating temperature of 1900-2000°C.

The first stage in the ACT-ARP-concept is to be operated in the slag resistance mode with two top-electrodes submerged into the bath. The main objectives to be tested in the “Stage 1 Smelting” are:

- Definition of slag-characteristics relative to slag resistance smelting for the relevant slag compositions, including:
  - Electrical characteristics
  - Viscosity characteristics
  - Thermal characteristics
  - Chemical characteristics

In order to have surplus energy available we intend to combine our largest power supply (1500 kVA, AC) with a furnace pot normally linked to a 300-kVA transformer. The control system is flexible and the electrodes can be moved individually, in the manual mode or automatically by set point values.
The furnace pot (900x600, depth = 600mm) has a double outer steel-casing covering the area from the bottom and 500 mm up. Vertical channels lead the cooling oil up and down all the way around. A pump drives the oil from an oil circulating system where in addition the returning hot oil is cooled in heat exchangers.

Inside the pot we will put in a high quality alumina lining. The oil cooling will establish a freeze lining.

The furnace pot is equipped with two tap holes, one at the bottom and the other 120-mm above. In addition a cooled top with openings for material injection, electrodes (sealed openings) and furnace gas outlet, will be constructed.

Agglomerated alumina and Carbon, with different Alumina to Carbon ratios, will be used as feed material. Accurate feeder system to the furnace is crucial and will be installed.

To be able to control the process and to verify the fundamental feasibility of step 1, it is of crucial importance to monitor the carbon content in the slag. Rapid chemical analysis of slag samples by the LECO-method will be performed.

We believe that a substantial bath is necessary to obtain the stable conditions needed to record electrical characteristics data of the slag. A bath depth of 300-400mm will probably be needed to obtain useful slag-characteristics.

Two tap-holes on the furnace pot and the tapping equipment in the Test facilities allow tapping of the furnace and smelting of new batches. The tapped materials may later be used in a stage 2 simulation test.

Stage 2 smelting: The $\text{Al}_4\text{C}_3$-content in the slag will be raised to a level which gives best possible conditions for aluminum production. The energy input to raise the slag temperature to a level necessary for producing aluminum (2100-2200°C) will be realized by means of side-wall electrodes to avoid shortening due to the formation of a metal-layer on top of the slag bath. The side wall electrodes will be installed at an appropriate level from the bottom of the vessel but below the aluminum layer. The experimental procedure for the Stage 2 Smelting Tests will be as follows: Firstly, the slag from stage 1 is remelted using the top electrodes. When a sufficient bath is established, the power supply is switched to the side wall electrodes and the temperature is increased to 2200°C. The bath composition will be adjusted by adding alumina, alumina-carbide mixtures or slag from stage 1 testing. An effort to collect aluminum with a high content of carbide will be incorporated in the test program.

Vapor recovery reactions: The high temperature of the reaction in Stage 2 will cause high Al and $\text{Al}_2\text{O}_3$ vapor losses. To prevent high Al-losses the vapor/ gas must be recovered. The test program will therefore also include investigations of the reactions in the vapor recovery units.

The tests will be performed in a 60 kW laboratory scale reactor by installing a sideport to the furnace acting as a charge column (figure 3). Different materials like petrol coke, alumina-coke agglomerates, reactive charcoal will be tested. Reaction products and corresponding temperatures in the column will be investigated.

The laboratory scale testing facility for the stage 1 test (figure 4) is now under construction at the pilot plant at Elkem ASA Research in Kristiansand and the first experiments are scheduled to take place after the summer holidays. The vapor recovery tests will start this month. The total initial program described above is scheduled to be finished December this year.
Figure 3: Experimental setup for the vapor recovery experiments

Figure 4: Experimental setup for stage 1 experiments
The Development Plan

The project plan is focused on two major technical tasks:

1) Determination of Fundamental System Properties and Parameters, which includes computer models for the reactor and vapor recovery units, experiments to determine the reaction kinetics and operating parameters of vapor recovery and estimation of critical properties such as slag viscosities.

2) Evaluation of the Advanced Reactor Process, in which the feasibility of the two reactor stages are independently determined in 0.5 to 1.0 MW large laboratory scale units. The first half of the program is scheduled for 2000, followed by a demonstration of the combined stages on a larger scale in 2001.

If the evaluation program is successful, the next phase of development will be a 3-4 year project at the 10 to 15 MW scale.

Final remarks

The schedule for the proposed program to develop the Advanced Reactor Process is aggressive, especially considering the technical hurdles that must be overcome to demonstrate a successful process. Although the risk is high, the benefits in cost, energy and environmental are quite significant. The advanced fundamental understandings, the identification of problems experienced by previous attempts, and Elkem’s metallurgical and engineering expertise in high temperature processes all provide the basis for tailoring proven reactor design concepts to the production of aluminum by carbothermic reduction.

References