OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

07769

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.250/8
16 May 1977

ENGLISH

Meeting on Case Studies of Aluminium Smelter
Construction in Developing Countries

Vienna, Austria, 27 - 29 June 1977

CONSIDERATIONS FOR A MAJOR ALUMINUM SMELTER PROJECT[1]

by

J. A. Lang and E. P. White*

---

* Aluminum Company of America, Pittsburgh, Pennsylvania, U.S.A.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.77-3503

Since 1970, primary aluminum capacity has increased about 40% throughout the world. The fastest growth rate has occurred in the developing countries and will probably continue to do so. These countries are in good economic position to increase the use of aluminum within their own borders. Further, they generally have one or more of the following: available work force, available raw materials and contacts with primary aluminum producers who are willing to take an equity position or make outright sale of technology and technical assistance. There is also an interesting incentive for these countries - the possibility of aluminum exports to increase their balance of payments.

Commercial production of aluminum today is by the Hall-Heroult electrolytic cell process. It is appropriate to define the two principle cell designs used in this process - the "prebake" cell and the "Soderberg" cell. The Soderberg design uses a single large carbon anode for which carbon paste is fed periodically at the open top of a rectangular steel compartment and which is baked by the heat of the cell to a solid coherent mass while it moves down the casing. Electric current is introduced into the Soderberg anode by spikes or studs which project into the anode paste either horizontally (HSS cell) or vertically (VSS cell). The VSS cell has been more generally used in recent times because it alleviates some of the environment problems within the potroom in comparison to the HSS cell - although at some sacrifice of operating performance. In contrast to both HSS and VSS cells, modern "prebake" cells use a number of anodes suspended in the electrolyte, the anodes having been formed from carbon paste and previously baked in a separate furnace or kiln.

Therefore, the first consideration in smelter planning is: Soderberg technology versus pre-bake technology? Each is "the right choice" under certain circumstances. From the 1920's to the 1960's the Soderberg system was widely recommended. Investment costs for Soderberg smelters in the range of 50,000 MTPA were clearly lower than for prebaked anode smelters - simply because an anode plant and baking furnace installation was not required. Furthermore, continuing improvements in Soderberg operation increased efficiences, reduced work input and lowered the cost per kg of aluminum produced. For these reasons, Alcoa built a 20,000 MTPA Soderberg smelter for its affiliated company, Aluminio S.A. de CV, Mexico in 1963, and then increased that capacity twice to a total of 45,000 MTPA as of 1971. Alcoa affiliate Alcominas, in Brazil, started production in 1970 at a rated capacity of 25,000 MTPA - with subsequent expansion to a present total of 60,000 MTPA - all Soderberg reduction. Suriname Aluminum Company, SURALCO, started production in 1965 with a Soderberg potline of 45,000 MTPA capacity and expanded it to 66,000 MTPA in 1969. The advantages of the Soderberg technology over prebaked anode smelter systems can be summarized as follows for the moderate production range of 10 to 75,000 MTPA:

1. Lower investment cost.
2. Reduced manpower requirements in the more highly skilled categories.

However, beginning in the 1960's increased emphasis was placed on prebaked anode smelters. The economies of scale, the increased demands of the market place and the pressure of environmental considerations - all have increased the popularity of the prebake system. Considering capacities of 100,000 MTPA and over, prebake potlines offer the following advantages:

1. Lower total investment cost
2. Lower total manpower requirements
3. Lower power consumption
4. Lower carbon consumption
5. Easier protection of the environment for both the worker and the community

Soderberg potlines have been popular choices with many smelters sized initially or ultimately to be 75,000 MTPA, but industry has favored the prebake potline in more recent years when ultimate capacity was to be 100,000 MTPA or more. For Soderberg smelters, the initial savings from not building a carbon baking furnace and rodding room are noticeable. Often overlooked, however, is the fact that investment costs for the Soderberg pot itself can be slightly more. Also, the cost of molten metal produced may be higher in a Soderberg potline, if depreciation costs are not counted. With energy costs increasing, Soderberg operating costs becomes still higher in proportion. The choice, then, must be to put more investment in pot design for lower current density and subsequently power cost - or live with a higher incremental power cost. Normally, more workers are required in a Soderberg potline than in a prebake potline. This fact has become more meaningful as workers resist the demanding working conditions in a Soderberg potline. Costs are rising fast for environmental equipment - and even more so in a Soderberg design.

In the foregoing comparison, it is obvious that the smelter capacity range of 75 - 100,000 MTPA appears to be a "land of no decision." It is an area of smelter size for which either the Soderberg technology or the prebake system might logically be specified. Such a decision will be influenced by factors of:

1. Plans for future expansion.
2. Availability of suitable manpower.
3. Specific environmental requirements for both the community and the worker - including the need for heat protection in high temperature climates.
4. Cost of both financing and technology.

Capacity

The Aide Memoire prepared by UNIDO for this conference mentions a number of developing nations where smelters have been built or construction is contemplated. If one examines capacities as of 1976, the following breakdown can be made by country and number of smelters, grouped according to capacity in thousands of metric tons per annum:

EXISTING FACILITIES

1 - 25	26 - 50	51 - 75
India - 1	Brazil - 3	Brazil - 1
	India - 2	Cameran - 1
	Iran - 1	Suriname - 1
	Mexico - 1	Turkey - 1
	Venezuela - 1	

76 - 100	101 - 150	151 - 200	201 Plus
Egypt - 1	Argentina - 1	Ghana - 1	
India - 1	Bahrain - 1		
	India - 1		

Announced or Contemplated Facilities

76 - 100	101 - 150	151 - 200	201 Plus
Phillipines - 1	Algeria - 1	Venezuela - 1	Brazil - 1
Brazil - 1	Dubai - 1		Indonesia - 1
	Iraq - 1		

Looking at announced or contemplated smelters, all but the two smaller ones in Brazil and the Phillipines are of a size for which today's criteria would indicate the prebake pot design. To the best of our knowledge, this decision has already been made for those smelters in Dubai, Indonesia, Venezuela and Brazil. Thus, it appears that most future smelters will be of prebake design and that economies will dictate a capacity approaching 100,000 MTPA - or more.

Investment Cost

A major concern in selection of smelter technology is initial investment. A study of smelter investment costs is not an accurate method of comparing the cost of facilities. Nevertheless, if one surveys published information on smelters in the last ten years, it seems that the breakeven cost for both Soderberg and prebake types may be in the range of 80 to 90,000 MTPA. By adding concern for energy and environment, the tendency is to push this point toward the 60 to 80,000 MTPA level. Furthermore, with regard to operating costs, productivity calculated from publicity releases seems to show that Soderberg smelters may require as much as 30% more employees per ton of installed capacity as do prebake designs at this production level.

Site and Environmental Considerations

Most smelters announced for the developing countries, and others yet unannounced, will have site conditions different from smelters in industrialized nations but quite similar to those in the developing nations; such as, Suriname, Egypt, Bahrain, Ghana and India. Conditions of climate and manpower availability must be considered. Infrastructure may be a large expense. In a world more cognizant of environmental problems, investment cost must include facilities for proper control of air, water, noise, and solid waste. For example, a tidewater location may be favorable to shipping costs, but most host nations do not want pollutants to be run into the sea water nearby. Equally, fluoride and hydrocarbon fumes may be objectionable for the local atmosphere. On the other hand, it may also be that the smelter would be located where environmental concerns are unnecessary. As an indication of the considerations in this area, Appendix I gives general information on the Alcoa processes and methods for reclamation of fluorides, removal of hydrocarbons plus reduction of in-plant environmental hazards.

Size of Potline

As indicated, most new smelter potlines are being specified in terms of 60,000 to 100,000 MTPA for each unit and using the prebake system. Potlines of 240 pots are reported and some of 250 to 260 pots have been proposed. Generally, this number will be of no problem with respect to pot technology or to the plant electrical system (transformers and rectifiers). Alcoa itself has potlines of the size indicated.

As an example, a potline producing 75,000 MTPA at 170,000 amperes requires about 168 pots. To produce 100,000 MTPA at 170,000 amperes requires about 224 pots. Then, 60,000 MTPA is 136 pots.

Here a word of warning is needed despite the trend to very long potlines. Each pot in these potlines will require about 790 ACKW. Thus, the 75,000 MTPA will require about 133,000 ACKW, allowing for various electrical losses. Any potline taking 135 MW or 135,000 KW can make a disproportionate demand on a power grid. The 100,000 MTPA potline will require 190,000 ACKW, with an even greater effect on the local power grid. In such cases it is suggested that the planning authorities consider a 120,000 MTPA smelter with two potlines instead of one. Here the power take will be about 265,000 ACKW; yet, the big change is that now only 132,500 ACKW are used in each of two potlines.

Another point to consider is that any potline of 100,000 MTPA will take 900-1,000 volts. Such potlines require dedicated maintenance and well-trained technical personnel to maintain equipment and to insure the safety of the potroom employees. To reduce this problem, the answer again can be to increase the total capacity of the smelter -for example, from 100,000 MTPA to 120,000 MTPA and to use two potlines requiring only 625 volts each.

On the mechanical or metallurgical side, the number of pots per line and potroom should also be considered - with special regard to training requirements. As outlined under the heading of Training, the efficient operation of a properly designed smelter depends on a properly functioning, properly trained, competent staff from superintendents and foreman to the laborer in a carbon changing crew. It is easy to understand that a larger number of pots in a smelter line places a greater responsibility on both the foreman and the hourly paid workman. This increased responsibility, then, reflects upon the training required for the various individuals, with a lesser amount of training being required for the smaller potline and a greater amount of training needed for the larger line. All other considerations being equal, it is easier to train men and to reach optimum efficiency on a potline of 100 pots than on a potline of 200 pots.

Training

In any case, training of operating personnel and the establishment of a fully staffed organization is critical to the maintenance of best operating efficiency. Since variations exist in working practices as well as in standard labor classifications, it is not appropriate to outline a Manning Table in any general report. For general consideration, however, the various categories of personnel typical for an Alcoa P-155 prebaked anode smelter are given in Appendix II to this report. With respect to training, in-plant experience should be coupled with classroom lectures. Such training is recommended for key operating personnel first at an existing smelter for the following job responsibilities:

Works Manager
Production Manager
Technical Manager (or Chief Process Engineer)
Potroom Superintendent
Electrode Superintendent
Potroom Foremen - Potroom Technicians - Potmen
Electrode Foremen - Electrode Technicians - Process Operators

The need for full and adequate training cannot be overemphasized. Without properly trained managers, superintendents, foremen, and pot crewmen, it is not possible to achieve the full potential of any smelter. In the above list Foremen, Potroom Technicians and Potmen are specifically mentioned to emphasize the need for training of this caliber of personnel in an operating facility belonging to the technology vendor before the training and start-up program is initiated at the new smelter. Full and complete programs for such vendor training should be developed - complete with provision for both instruction and operations manuals. Obviously, any program should be based on the education, training, and mechanical aptitude of those to be trained.

Smelter start-up and training of the full operations personnel may then be carried out partially at the technology supplier's plant and largely at the site of the new plant with assistance from the technology supplier. For smelter start-up and on-site training, the supplier's personnel should typically include personnel with the following backgrounds:

<u>Production Management</u> - one person who would assist in coordinating all electrode plant, potrooms and ingot plant activities and make necessary contacts with technology supplier. This person also would be involved in Process Control wherever appropriate.

<u>Production Superintendents</u> - should be available for several months to assist the Client's superintendents and staff in specific training and technical consultation activities.

Process Engineers - such personnel can assist on start-up, plant operations and training, as well as certain phases of construction and commissioning activities.

Technical Foremen - capable supervisory employees with technical expertise in preoperation and operation phases of a smelter. Such individuals may be involved in monitoring production activities during the construction of the smelter just prior to the start-up. These technical foremen would assist on the commissioning and start-up of the smelter where such experience "from the floor" is of immense value. These men might also be made available for several months to assure coverage of the smelter seven days per week, 24 hours per day. In all cases they would work with the customer's foremen to assure that the latter have learned as much as possible. The total time required for this training staff would vary depending on need - ranging from periods of three months to one or two years.

Products

Product mix for future smelters will be varied depending on probable customer demand. Modern ingot casting equipment is expensive; so it is important to determine product mix as accurately as possible. Continuous cast conductor bar and sheet reroll stock are a stable part of a smelter's local market. However, as industrialized nations start depending more and more on developing nations for ingot, the industry needs may call for other products. For example, one of Alcoa's overseas smelter affiliates makes very high quality extrusion billet and sheet ingot for quality conscious customers in both Europe and North America. Furthermore, if semi-fabrication activities are eventually planned, then smelter layout and service facilities should be designed to have efficient operations for that future time. For consideration, Appendix III reviews a variety of "Cast House" or "Ingot Plant" equipment which Alcoa feels should be considered in planning this final stage of an aluminum smelter - given as related to a specific "example" study. Again, caution must be exercised lest too many ingot products be specified, creating a disproportionately high cost of facilities. Sellers of export ingot should keep in mind that sales revenues can often be increased if high quality (both chemical and physical specifications) are offered to customers in contrast to lower grade remelt ingot or 500 Kg "sows."

Cost Study

In order to make the best judgment possible in respect to any aluminum smelter, a cost/feasibility study should be made. Properly done, such a study will assist in major choices such as location, capacity and the selection of technology. Perhaps, such a study might even indicate that no smelter should be built at all. In any case, whenever large sums of money are involved, it is good business judgment to make sure that all factors in the project have been adequately studied and that a reasonable economic basis is established.

The objectives of the study could thus be stated as follows:

1. Provide proposed plant and infrastructure layout for selected site.
2. Provide general process and equipment proposal - generally covering all phases, with cost estimated but without details of equipment and process engineering.
3. Provide estimate of manpower requirements with probable training costs.
4. Determine probable sources of construction materials and construction equipment.
5. Determine probable sources of plant equipment.
6. Determine probable sources and quantities of plant operating materials and facilities (power, water, etc.).
7. Evaluate cost and schedule impact of major site factors.
8. Evaluate the approximate cost ratio of the local site versus other known production sites.
9. Determine anticipated rate of cost escalation where possible.
10. Provide general estimate of operation cost and subsequent cost of ingot metal products.

In order to make the study, it would be necessary for the proper personnel to visit the plant site to obtain project requirements from local authorities and to confer on all necessary raw materials, requirements for power and other facilities, construction engineering, procurement and financing.

The purpose of such a study would be to outline the various cost factors involved with sufficient reliability to determine the feasibility of the project - or at least to establish dependable cost relations and amounts for the various decision options available.

On a standard basis, Alcoa requests access to certain specific information in order to perform a cost/feasibility study. A list of the "Information Required" and "Contents" as used by Alcoa are given in Appendix IV as a reference.

Total Estimated Cost of Aluminum Produced

After considering all factors such as, type and size of smelter, location, manpower, etc. - the final consideration must be the estimated total cost of aluminum produced. Without a competitive cost for the intended market, the entire smelter project could be a disaster. In this context, total cost includes operating cost, overhead, and investment cost. The operating cost would include raw materials, power, labor, miscellaneous materials, and ingot casting cost. The elements of operating cost must be determined on the basis of the system chosen, the source and price of raw materials and power - and the cost of manpower, per the following:

DIRECT RAW MATERIALS COST

Alumina
Electrolytes

Carbon
    Coke
    Pitch

Potlining Materials

    Total Direct Materials

OPERATING COST

Direct Materials

Payroll (including Ingot & Plant Administrative Expense)

Power

Repair and Maintenance Materials

OPERATING COST (Continued)

Miscellaneous Materials

Ingot Casting Fuels, Melt Loss and Materials

Total Except Depreciation, Corporate Overhead, Taxes and Sales Expense

Overhead would include such items as taxes, corporate overhead, selling expenses and such other expenses not directly related to Smelter operation. Inclusion of items for overhead will depend upon the accounting system and business practice of the corporate entity or enterprise involved.

In this discussion it is assumed that a smelter, like any other industrial plant, is required to recover a certain percentage of its investment cost annually through sales of its products for the purpose of paying off the total facility cost. For example, a firm with a target of 15% return on investment would be required to charge $150,000 in the products annually for each $1,000,000 cost of investment. That investment would be the initial total cost of the facility.

For purposes of example, there is shown on the following table (for a 240,000 MTPA smelter) a return on investment of 10%, 12%, 14%, 16% and 18%. Costs of installed capacity per ton of metal have been indicated at $1,400, $1,600, $1,800, $2,000, $2,200, $2,400 and $2,600/MT (all U.S. dollars). Within this range, it is then possible to find a value close to the values for designs under consideration.

Investment Cost	c/kg Al for Investment				
per MT of Capacity	10%	12%	14%	16%	18%
$1400	14.00	16.80	19.60	22.40	25.20
1600	16.00	19.20	22.40	25.60	28.80
1800	18.00	21.60	25.20	28.80	32.40
2000	20.00	24.00	28.00	32.00	36.00
2200	22.00	26.40	30.80	35.20	39.60
2400	24.00	28.80	33.60	38.40	43.20
2600	26.00	31.20	36.40	41.60	46.80

Thus, for example, if the estimated cost is $2,000/MT of capacity, the total cost of a 240,000 MTPA smelter is $US 480,000,000. If it is desirable under the financial guidelines to recover 14% of the investment annually, then an annual sum of $67,200,000 must be included in the total sales return for the product to pay for the investment. On an incremental basis, this return would be 28.0¢/kg Al. This investment cost, when added to the estimated operating cost plus overhead would give the total cost of aluminum produced.

In this manner it is possible to determine the total real cost of aluminum produced. Not to make such a determination as a part of the planning exercise is to invite serious problems.

SUMMARY

1. Prebaked Anode vs. Soderberg Smelter Design:
As the demand for aluminum increases - with emphasis on both low cost production and protection of the environment - the trend today is toward larger smelters and greater use of prebake pots for smelters.

2. Size of Potline:
Optimum efficiency must balance the variable factors of investment cost, power requirements, manpower availability in order to establish a "best" choice in potline size. What is a proper choice for one location may not be the right selection for another.

3. Training and Qualification of all Personnel:
An aluminum smelter requires a substantial initial investment. Therefore, it is absolutely essential that this investment be protected by proper training of all personnel in all phases of operation, maintenance and supervision. Technical qualification and proper understanding of operation requirements is critical in respect to plant management and supervisory personnel.

4. Ingot Plant Provisions:
An integral part of any smelter must be its Cast House or Ingot Plant. If the product of the smelter is not of the proper quality or offered in the desired form, it will not maintain a good sales performance. At the same time, the cost of ingot plant must be balanced against both the market needs and the facilities cost.

5. Planning and Cost/Feasibility Study:
All aspects of an aluminum smelter should be thoroughly studied before final decisions are made in respect to location, type, size, products and overall economics. A significant part of such study is the final determination of the price of aluminum to be produced.

APPENDIX I

Environmental Protection Processes

The Alcoa 398 Process controls the gases and solids evolved from the smelter pot and its electrolyte. This Process recovers 98.5% or more of total fluoride from the collected smelter pot gases (gaseous and particulate fluoride) and affords a completely dry process not subject to ambient temperature extremes. In addition to abatement of air pollution, the Alcoa 398 Process recovers the electrolyte constituents in a directly re-usable form, thus permitting a significant operation saving through the recovery of the electrolyte constituents in a directly re-usable form. This latter aspect permits a significant operation saving through the recovery of fluoride and alumina, reducing aluminum fluoride consumption by as much as 50%.

In this Process the collected gaseous and particulate matter are forced through a moving fluidized bed of metal grade alumina. The gaseous fluorides are chemisorbed on the alumina while solids are trapped in the alumina bed. The alumina and other particles blown out of the bed are caught in filter bags. The fluoride laden alumina from the fluidized bed and from the filter bags is then moved to storage tanks for use in the smelter pots.

The Alcoa 446 Process is one in which the hydrocarbons from the Carbon Plant furnace are collected and concentrated on a small amount of alumina where they can be incinerated with a relatively small fuel input. By maintaining a high enough hydrocarbon content on the alumina, combustion of the hydrocarbons in the incineration step can be made almost self-sustaining thus reducing the amount of fuel required. The hydrocarbon removal efficiencies obtained to date have ranged from about 95 - 98% with a typical hydrocarbon outlet loading of .001 Grain/SCF. This grain loading is well below the level of visibility, a fact which is readily confirmed by the clean appearance of the stacks. In addition to eliminating the hydrocarbon fumes, entrained coke dust is also removed in this Process and serves as supplementary fuel in the regenerator. Because the fluorides are fixed chemically, none are released when the alumina is regenerated. The regenerated alumina is recycled to the reactor or conveyed to the potroom.

Alumina and coke conveying systems apply dust control equipment throughout. Alumina is transported from the track hoppers via screw feeder - belt tripper and airslide into storage tanks. Recovery from the main storage tanks and conveying to the potroom tanks is via screw feeder - shuttle belt - inclined blet - screen - and sawtooth type belt systems. Coke is transported from the track hopper screw feeder - belt conveyor - belt tripper and into main storage tanks. Each belt/belt transfer, and belt/tank transfer is serviced by dust control equipment consisting of a fabric type dust collector, an exhauster, ductwork and batch handling equipment.

APPENDIX II

PERSONNEL CATEGORIES FOR

ALCOA P-155 PREBAKED ANODE SMELTER

Potroom

I. Supervision and Staff

Potroom Superintendent
Process Engineer
Potroom Shift Foremen
Potline Control Technician
Aluminum Plant Clerk
Potroom Technician

II. Semi-Skilled Labor

A. Tapping Crew
   1. Cranemen
   2. Pot Serviceman

B. Anode Setting Crew
   1. Cranemen
   2. Pot Serviceman

C. Potmen

D. Potroom Labor Pool

Potroom Service Department

I. Supervisors & Technicians

Foreman
Fume Control Technician

II. Labor Semi-Skilled and Unskilled

A. Material Processors
B. Tool Repairman
C. Equipment Operators
D. Bag House Repairman
E. Control Helpers
F. Janitors
G. Laborers - Unskilled

Electrode Plant

I. Supervisory and Staff

Electrode Plant Superintendent
Process Engineer
Anode Supervisor
Foremen
Technicians
Clerk

II. Labor Semi-Skilled and Unskilled

Anode
- Anode Producers
- Baking Furnace Operators
- Cranemen
- Packer - Pullers
- Laborers

Rodding
- Furnace Operators
- Assembly Operators
- Truck Operators
- Laborers

Cathode Repair
- Leadmen
- Potliners
- Equipment Operators
- Laborers

Ingot Plant

Job classifications will depend on product mix of the smelter, but might include:

I. Supervisors and Staff

Ingot Plant Superintendent
Metallurgist or Process Engineer
Casting Shift Foremen
Casting Unit Foremen
Technician
Clerk

II. Labor Semi-Skilled and Unskilled

Furnace Operators
Casting Unit Operators
Casters
Truckers
Laborers

APPENDIX III

INGOT PLANT, BUILDING AND EQUIPMENT

Alcoa Castings Systems and Equipment

To cover all casting systems used, design engineering and construction details should be included for ingot plant equipment and facilities to receive molten metal in potroom crucibles, to weigh, to transfer into furnaces and alloy and to cast ingot of the proper configuration for subsequent fabrication or remelting. Capability to remelt internally generated ingot and furnace scrap should also be included, along with supporting facilities to process furnace skim, analyze ingot quality, homogenize, saw, handle, pack and ship the ingot products.

Alcoa 469 Process - Fumeless Molten Metal Degassing and Filtering

While the Alcoa DC and Level Pour casting systems can be used directly from the holding furnace, the resulting ingot product is found to be even more satisfactory for both general and premium quality use, when it has received an Alcoa 469 Process fumeless metal treatment for filtering and degassing. Alcoa's fumeless in-line fluxing and filtering systems require neither fume collection nor fume treatment processes. Air pollution and in-plant damage due to corrosive chlorine and chloride fumes from furnace fluxing are eliminated. This treatment not only reduces non-metallic inclusions and hydrogen to achieve premium quality metal, but also removes trace elements such as sodium and calcium to maintain a molten aluminum product suitable for high quality applications from die castings to premium forgings. The Alcoa 469 Process is a full production process suitable for any constant, high level casting schedule.

Assumed Ingot Plant Task

The following equipment and facilities are capable of handling up to approximately 240,000 MTPA of potline molten metal and convert it to specific alloys and products. The size and weight ranges as well as the tonnages for the products are listed below:

Product	Size	Potline Molten Tonnage
Sheet Ingot	300 mm X 1500 mm X 1000 to 2000 mm long after cutting	50,000 MTPA
Extrusion Ingot	100 to 400 mm dia. X 300 to 600 mm long all cut to length	

Product	Size	Potline Molten Tonnage
Strip Cast Reroll Stock	6 to 12 mm thick X 1800 mm wide strip	40,000 MTPA
Rod (EC)	9 to 20 mm dia. 5000 Kg coils	70,000 MTPA
Remelt Ingot	500 Kg saws	80,000 MTPA
Potline Molten Total		240,000 MTPA

In establishing this ingot plant task, as an example, it was assumed that no fabricating scrap would be handled in this facility and only generated scrap from the ingot plant would be remelted in the furnaces provided.

Product	Ingot Plant Equipment
Sheet and Extrusion Ingot	Vertical casting unit complete with two melt-hold furnaces and two Alcoa 469 filter systems. DC tooling on this unit will produce up to 250" (6,350 mm) long sheet ingot using 100,000 lb. (45,400 kg) drops per cast. FDC tooling on this unit will produce extrusion ingot 8" (20.3 mm) dia. and larger by 250" (6,350 mm) long with average drop weights of 60,000 lbs.
Small Dia. Extrusion Ingot (4" to 7" Dia.) (102 mm to 178 mm)	Horizontal casting unit complete with two melt-hold furnaces, one Alcoa 469 filter system, flying cut-off saw and runout conveyor.
Reroll Stock	Strip Casting Units complete with one melt-hold furnace, one Alcoa 469 filter system, shear and coiler.
EC Rod	Continuous rod caster, rolling mill and reel type twin coiler system with two melt-hold furnaces and one Alcoa 469 filter system.
Extrusion Ingot	Homogenizing furnace complete with a load cooler, two load cars and a transfer car for homogenizing extrusion ingot. Circular cold saw system complete with ingot handling conveyors, chip collection and cut ingot stack and bundling equipment.
Sheet Ingot	Circular cold saw system complete with ingot handling conveyors and chip collection for cutting sheet ingot to desired lengths.
500 Kg Remelt Ingot	Open Mold Bench Line.
Skim Processing	Alcoa rotary barrel skim processing and cooling systems, complete with rotary barrel unit, cooling drum, hooding, ducts and fume and dust collection baghouse.

Capital costs for the DC, Level Pour and HDC casting system - with or without a fluxing, filtering and degassing system - will vary significantly depending on the size and type of unit, size of ingots, production rate, and other factors. With a possible variation from \$300,000 to \$50,000,000, it is not reasonable even to suggest a probable range of costs until certain data is available on the specific production requirements. In order that the most accurate estimate can be made for metal treating processes and casting systems, it is desirable to have as much information as possible on the following:

Type of metal to be cast: Primary
Scrap - clean or with contaminants of oil, paint or other materials

Alloy(s)
Size of ingot(s)
Annual quantity for each ingot size - alloy combination
Length of production casting run for each ingot size - alloy combination
Desired surface characteristics
Desired internal (metallurgical) characteristics
Intended end use
Desired operating schedule (shifts per week)

APPENDIX IV

COST/FEASIBILITY STUDY

I. INFORMATION REQUIRED FOR STUDY

1. Site Visit

Restriction in size
Weather condition - soil conditions - accessibility, etc.
Port and/or general transport facilities - availability - capacity - type (land and water)
Power and fuel sources - availability - reliability - cost
Raw material sources - availability - reliability - cost

2. Labor Availability

Skills
Supply - numbers and time (how many of each skill) (how soon and how long)
Cost - wages and benefits costs - for construction and operating

3. Methods of Normal Procedure for Project Work

Responsibility for engineering
Responsibility for approvals
Responsibility for contracting work on site
Responsibility for furnishing of labor
Responsibility for construction equipment

4. Procurement Opportunities

Material) specifications and estimated
Machinery and equipment) delivery lead times
Special fabrication

5. Procurement Restrictions

Finance restrictions
Country sources for material and equipment
Limitations on types of equipment or % total contract

6. Governmental Restrictions

Building Codes
Environmental requirements

COST/FEASIBILITY STUDY

CONTENTS

G. Outline of Ingot Plant

Product mix requirements
Layout and equipment recommendations
Analysis of need for Alcoa 469, molten metal filtering and degassing equipment

H. Review of Service Facilities

Maintenance
Machine Shop
Laboratory
Services - compressed air, stream electrical
Location and specifications

IV. Labor Requirements and Operating Procedures

A. Construction
B. Operation
C. Training required

V. Estimated Cost Requirements

A. A capital cost estimate to include all necessary buildings and equipment as well as initial raw material stocks.
B. An estimate of operating costs
C. A schedule of engineering, procurement and construction needs and time flow charts
D. Estimated engineering and construction cash flow curves

C-673

78. 11. 10