Paper Title:

THE ISASMELT PROCESS – OPERATING EXPERIENCE OF A SECONDARY PLANT

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Abstract

The emphasis on lead usage is moving steadily towards battery manufacture, with a projected rise to around 75% by the end of this decade and an increasing responsibility towards producers, consumers and recyclers. (Refer to Dia. 1) Following an in depth study, Britannia Refined Metals Ltd. embarked on the development of its secondary business at the Northfleet site. The construction of a new secondary refinery was completed and began commissioning in June 1991. The plant incorporates modern battery breaking technology and advanced smelting technique using the ISASMELT process for lead recovery from the scrap stream.

Plant and process descriptions are outlined together with experience gained during operation of the plant to date.

Introduction

BRM Secondary Operations

The BRM site occupies a prominent riverside position near to the river Thames main crossing point for the London peripheral motorway. The site incorporates both primary refinery and the new secondary smelter. Secondary operations also include BRL (Britannia Recycling Limited) which is situated at Wakefield in West Yorkshire. The two sites both recycle scrap batteries and water materials associated with the lead/acid battery industry.

Scrap Handling

In the U.K. during the past two decades, economic restraints at the smelters and increasing environmental concerns have seen the majority of dismantling operations transferring to the smelters. Collection and delivery of the cased battery scrap is now mainly handled through an existing network of scrap merchants. Automotive batteries are expected to last for approx. 4 years or longer before replacement is necessary.

In 1992 licences were issued to 24 850 000 vehicles to use the national road system with a further 25 500 licences for electric powered vehicles. New registrations are currently running at 1.9 million per annum. There are also large numbers of batteries used in unlicensed vehicles, standby and emergency power systems. For the secondary lead recycling efficiency to operate at high levels approaching 100%, the introduction of supportive collection schemes need to be implemented and if necessary legislated for. (e.g. Levy schemes or mandatory take-back, with increased consumer education.) As many smelters are operating at or near a loss during a period when lead use for battery production is increasing, smoothing the flow of battery scrap back to the secondary smelter is paramount for future economic and environmental demands. The BRM plant has been designed to meet these criteria. (Refer to Dia. 2.)

Plant Technology

Apart from the existing rotary furnace and pyrometallurgical refining methods, the battery breaking and furnace plants were chosen as:

CV phase 1 and 2.

The CX plant is well engineered and is capable of producing high quality desulphurised paste as furnace feed with reduced levels of entrained separator materials. This material extends the operating cycle of the Isasmelt furnace due to the low impurity levels, giving minimised sulphur emissions. The CX plant is manufactured in Milan, Italy, by Engitec Impianti.

Isasmelt Furnace

The furnace can efficiently produce high quality bullion from the CX paste product. Mount Isa Mines Ltd. in association with CSIRO (Commonwealth Scientific and Industrial Research Organisation) have developed the ISASMELT process. Application to secondary lead production follows successful demonstration with the treatment of lead, copper and nickel concentrates in Australia. The innovative feature of the technology is the use of a top entry Sirosmelt lance and static compact vessel. Helical vanes inside the lance impart a swirling motion to the process air which freezes a protective layer of slag onto the outside of the lance. This allows the tip to be immersed in a molten slag bath for long periods. A highly intensive reaction takes place as feed material is quickly absorbed into the turbulent slag bath.

Effluent plant

CV effluent is handled using cross microfiltration technology. Precipitation and flocculation of dissolved heavy metals is carried out prior to entry into the plant. Filtration through a series of porous fabric tubes takes place where the solid precipitates form the body of the filter medium on the inside of the tubes. Clean effluent passes through the tubular membranes, is collected and stored prior to discharge.

Process Description

Battery storage

Incoming battery scrap is stored in a covered, drained building with internal access to the CX crushing mill via vibrofeeder and conveyer belt. Incoming scrap quality is closely monitored. Free acid is filtered and stored for treatment in the CX plant.

Battery breaking

Batteries are crushed in a hammer mill at 16 tonnes per hour. The paste fraction is separated on exiting the mill through a vigorously washed vibrating screen and into a stirred tank. The remaining washed compartments pass over the screen and are conveyed to hydrodynamic classifiers. The classifiers separate the remaining components and deliver streams of grid/poles, polypropylene, ebonite and PVC separators to storage bays. (Refer to Dia. 3 & 4)

Paste Treatment

Thickened paste slurry from the bottom of the tank is pumped to one of two reactor vessels. Liquid caustic soda is added to react with sulphate ions present in the paste. Any lead oxides are unchanged.

Reactions: $H_2SO_4 + 2NaOH = Na_2S + 2H_2O$

$PbSO_4 + 2NaOH = Na_2SO4 + PbO + H_2O$

When the reactions are completed, the contents of the reactor are passed through a filter press. The filtrate is sent to the effluent plant for further treatment. Following washing, to remove residual sodium salts, the filter cake is discharged and conveyed to a storage bin.

Acid electrolyte is treated in the same way. (Refer to Dia. 5)

Materials handling

Storage of the paste feed (CX filter cake.), reductant, grids/poles, fluxes, stockpiled paste and mixed fume dust are contained in storage bins and hoppers. The furnace DCS system can control and feed these materials to the furnace singly or combined via weighbelts and conveyors. The main feed stream of CX paste is transferred from the storage bin over a weighbelt to the conveyor system. All other materials are kept in covered storage bays and transferred to the feed hoppers using loading vehicles, thus reducing spillage to a minimum.

Isasmelt furnace

The furnace consists of a static cylindrical vessel which is refractory lined to give an internal diameter of 1.8m. It is designed to produce 35 000 tonnes per annum of bullion. (Refer to Dia. 6)

Desulphurised paste from the CX plant storage bin is continuously fed into a bath of molten battery paste together with coke as a reductant. The submerged combustion lance produces a highly turbulent bath as the paste feed is reduced to a low antimony soft bullion. The metal is intermittently tapped into pots via a launder system. On completion of each soft lead cycle, the slag is conditioned and reduced to produce a high antimony bullion and discard slag.

TABLE 1

Composition of Furnace Feed Materials

Material	Battery Paste	Grid Metal	Flue Dust
Pb%	66.20	90.8	60.0
Sb%	0.45	2.5	2.0
S%	1.00		

TABLE 2

Composition of Products

Material	Soft Lead	Hard Lead	Slag	Flue Dust
Pb%	99.8	79.2	0.5	60
Sb%	<0.1	20.6		2
Cu%	0.1	0.1		
FeO%			50	
SiO2%			25	
CaO%			15	

The furnace is operated on a semi-continuous basis. When smelting paste, soft lead is tapped every 3 hours. Antimony from the feed concentrates in the slag as oxide which gives a consistent soft lead bullion. When approximately 250 tonnes of feed material have been charged, metal is again tapped and additions of lime and iron made to give the required final slag composition. Similar procedures are adopted for grids/poles.

The reduction stage is commenced at this point with increased coal additions at elevated temperature. (1150-1250C). A ferrosilicate slag is produced with low lead content. After settling, the furnace is tapped for metal and slag. The operational parameters are outlined in table 3.

TABLE 3

Isasmelt Furnace Operational Details

Operation	Smelting		Reduction
	Paste	Grid Metal	
Bath temperature (C)	800-900	800-900	1200-1250
Feed Rate t/hr	10.0	18.0	
Air flow Nm3/s	1.40	0.9	1.70
Oil flow kg/hr	500	390	600
Coal rate t/hr	0.5	-	0.5

Plant operation – first year

CX Plant

The CX plant achieved the designed crushing rate of 16 tonnes per hour. However, early problems with separator fibres, polypropylene conveying and the computer/plc interface reduced utilisation of the plant. The filter press was unreliable and improvements were made to the operating programme. Paste transfer proved to be at the root of many problems associated with plant availability. Paste transfer pipes to the reactors suffered blockages as did the filter cake discharge from beneath the press.

Modifications were made to the screw collection system under the filter press with limited success. A new design was initiated while the other problems were being addressed.

The CX plant is coupled to the Isasmelt furnace by the paste storage bin which has a capacity of 200 tonnes. The CX plant suffered limitations to its utilisation following difficulties with the bin discharge screw. It is thought that residual sodium sulphate solution in the paste caused cementing of the material around the screw conveyor flights. Discharge rate declined to 6 or 7 tonnes per hour. This change occurred after commissioning of the of the phase 2 desulphurisation. A modified screw was fitted and the problem resolved.

The first year of commissioning and operation placed high demands on the operators and engineers. Many failures of small items such as pump shaft seals and electrical components occurred as a result of the learning process involved for reliable plant operation.

Isasmelt Furnace

Until the CX plant began operation, manually fed battery paste via temporary conveyors allowed the furnace to operate and continue commissioning. The attention focused mainly on lance flow measurements and the process control programming for the DCS system. As the CX plant supplied more feed, output from the plant increased due to the greater utilisation of the developing control system, up to period 6-1991. (Refer to dia. 7) The main difficulty on the practical operation rested with tapping procedure. Increased wear on water cooled tapholes resulted from inexperience with the methods involved. Further reductions in output resulted following loss of lance airflow calibration which took longer than expected to remedy. Inaccurate lance air caused difficulties with control of the slag bath depth. Coupled with a refractory reline, output was substantially reduced during period 10-12. (Refer to dia. 7) Production returned to a slightly improved performance by the end of period 13. During the first year of operation, the soft lead stage emerged as a flexible and robust process capable of producing high quality bullion. Grid metal from the CX plant was commissioned into the process after 6 months to augment the operation.

However, reductions in output through isolated case of equipment failure could not mask the underlying restrictions to performance which were split into two areas:

1) Feed transfer
2) Gas handling

Feed handling

The feed handling system reduced plant availability and demanded more of the operators' time than expected. Battery paste transfer caused problems with conveyor belts, transfer chutes, drive systems and screws. Modifications were actioned following analysis of specific problems throughout the system. During this time a high degree of effort was maintained by the production operators to keep the plant running.

Paste discharge from the CX plant storage bin was restored to design rate after screw modifications, then upgrading of belt and chute cleaning implemented while further improvements were considered.

Also in progress was the design and construction of additional feed handling equipment, which would replace the temporary conveyors used initially, to produce a more flexible system.

Gas Handling

The limits of capacity in the system were easily reached when the furnace began to achieve above design feed rates. Also, any difficulties with mechanics or instruments resulted in feed rate reductions in order to maintain acceptable hygiene conditions. Again, improvements were made to all parts of the system, especially controls in the baghouse itself and I.D. fan damper controls. It became clear that the system was too highly stressed and plans were made to erect and commission additional filter capacity by Dec. 1992.

Plant performance from period 1 – 1992

CX Plant

The phase 1 section containing hydrodynamic separation and discharge has presented few problems to date. Attention has been mainly focused on the phase 2 section and effluent plant. Standards of paste quality are improved and with the engineering experience gained since start-up, the plant is capable of exceeding the crushing rate of 256 tonnes per day. There are some longer term tasks to complete regarding the computer interface and programme improvements together with objectives for mill hammer life, oil cooling to the bearings and rotor changing.

In January, various changes were made to pipework, control valves and the filter press.

The replacement paste transfer equipment was installed under the filter press. A further increase in output was achieved as a result. Operation to crush forecast tonnage of batteries continued throughout February.

Isasmelt furnace

Having attained a peak in output during period 4, (Refer to dia. 7), some restrictions to production were addressed. Levels of soda in the furnace increased as more CX paste became available. The soda forms a separate layer and floats on the slag bath. The soda layer at times proved difficult to tap if the slag bath was not completely drained. The soda remained trapped in the furnace where it interfered with the protective coating on the lance tip. A second taphole has been installed at a higher level which allows tapping of the soda slag without having to drain the furnace.

Closer control of the plant operation with detail on temperature and reduction rate also contributed to record production in period 4. Following refractory reline in period 5, production was subject to restrictions in feed handling. A planned stoppage of the furnace allowed further design improvements to be installed on the conveyor system and gas handling. The results showed a further substantial increase in production in period 9. With the additional feed handling equipment planned for April commissioning, furnace utilisation is expected to increase further.

Final slag reduction is still under development and application to the furnace is being progressed. However, with the production of soft lead being maximised for the foreseeable future, the final stage of the originally envisaged five stage process will be developed and trialled when furnace time is available.

The reduction route at present involves two possible methods:

1) In situ reduction of the remaining slag bath following completion of soft lead production. Fluxes are added to give the final slag composition. All remaining metals in the slag are then reduced to give a high Pb/Sb alloy and discard slag.
2) Slag retreatment method of feeding crushed high lead slag to a low lead (30%-40%) slag bath. Lead level in the slag bath is maintained at 30%-40%. Flux composition is monitored and trimmed on the run. Lead is tapped and the slag bath depth checked.

When the slag volume has increased sufficiently, a full reduction takes place to give a high Sb/Pb alloy metal and insert discard slag.

Option 1) has displayed a tendency to foam at the start of reduction when the lead is high. (i.e., above 50%).

Other difficulties are encountered regarding the calculation of slag volume in the furnace for flux addition and small residual volume of slag after reduction.

Option 2) is favoured as a simpler operation which can be used to campaign pre-crushed slag. There are additional advantages:

- More accurate control of flux additions.
- Less thermal cycling of the refractory lining.
- Minimal foaming of the lower lead slag.

The life of the refractory lining and not reached satisfactory lengths to date and a development program is in progress with refractories and vessel cooling.

Feed handling

The conveyor system received improvement to the transfer points, drives and operator access during a planned shutdowns for work on the main chimney. On start-up the system allowed improved furnace operation during period 9. (Refer to dia. 7) This allowed the CX plant to operate and match the increased feed demand with a corresponding rise in output.

The additional feed system was installed and commissioning during April. The plant consists of a similar storage bin to the CX paste bin and conveyors which are integrated into the materials handling area. The more flexible and controlled feed system will improve furnace control.

Gas handling

The increased baghouse facility completed commissioning at the beginning of 1993. Process and hygiene gas handling capacity has been doubled to the Isasmelt and Rotary furnaces. Much improved operations have resulted, especially with Isasmelt, where changes to the filter bag construction and reduction to spray water in the process gas have improved the performance of the filter plant.

Effluent plant

Following the addition of extra settlement tanks from the original treatment plant, the filter curtain duration has been extended and curtain cleaning reduced. This is coupled with in situ acid washing which reduces the frequency of removing the curtains for cleaning. Manual operation of the control system is still favoured due to the fine limits placed on pH control.

Regular inspection and monitoring by the CX plant operators ensures consistent effluent quality is maintained to comply with the consent for discharge.

Table 4 lists the maximum discharge limits for the plant effluent.

TABLE 4

Maximum allowable effluent discharge limits

pH value		6.0 – 9.0
Max. volume of discharge (m3/day)		200
BOD (Biochemical oxygen demand)		10mg/l in 5 days at 20C
Dissolved metals in mg/l		
	Antimony	5
	Lead	1
	Zinc	1
	Arsenic	0.2
	Silver	0.1
	Copper	0.1
	Nickel	0.1
	Cadmium	0.05
	Mercury	0.05

Metal refining and moulding

Preparation of the finished products has continued with few problems to date. The increasing flow of metal from both furnaces will allow optimisation of ingot production from the kettle floor. Subjects for investigation will cover metal transfer from the furnaces, blending efficiency and procedure, using the two 120 tonne capacity refining kettles. The blending operation arises from the combination of a high quality soft bullion source provided by the Isasmelt furnace and more selective antimonial bullion produced from the Rotary furnace.

Conclusions

The issues affecting commissioning and development of the secondary plant at BRM have been discussed. The Isasmelt process technology for battery recycling through the secondary plant will continue to advance, with commitment to both quality and innovation. From the present foundation of operating experience, metal production is expected to be within forecast by the middle of 1993. Production costs will still be subject to completion of developments actioned during the early part of the year and are expected to meet forecast during the latter part of 1993.

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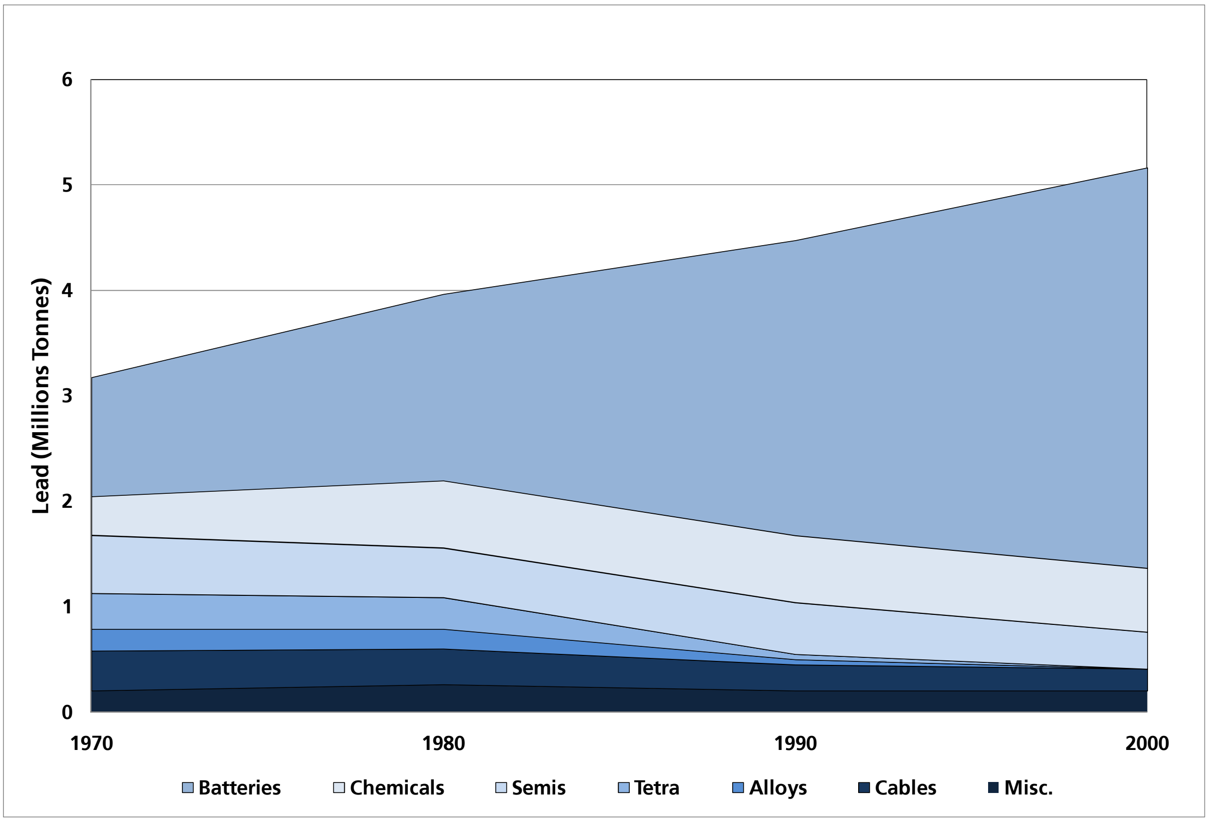

Diagram 1 Recent and Expected Development of Lead Consumption in the Western World by End Uses

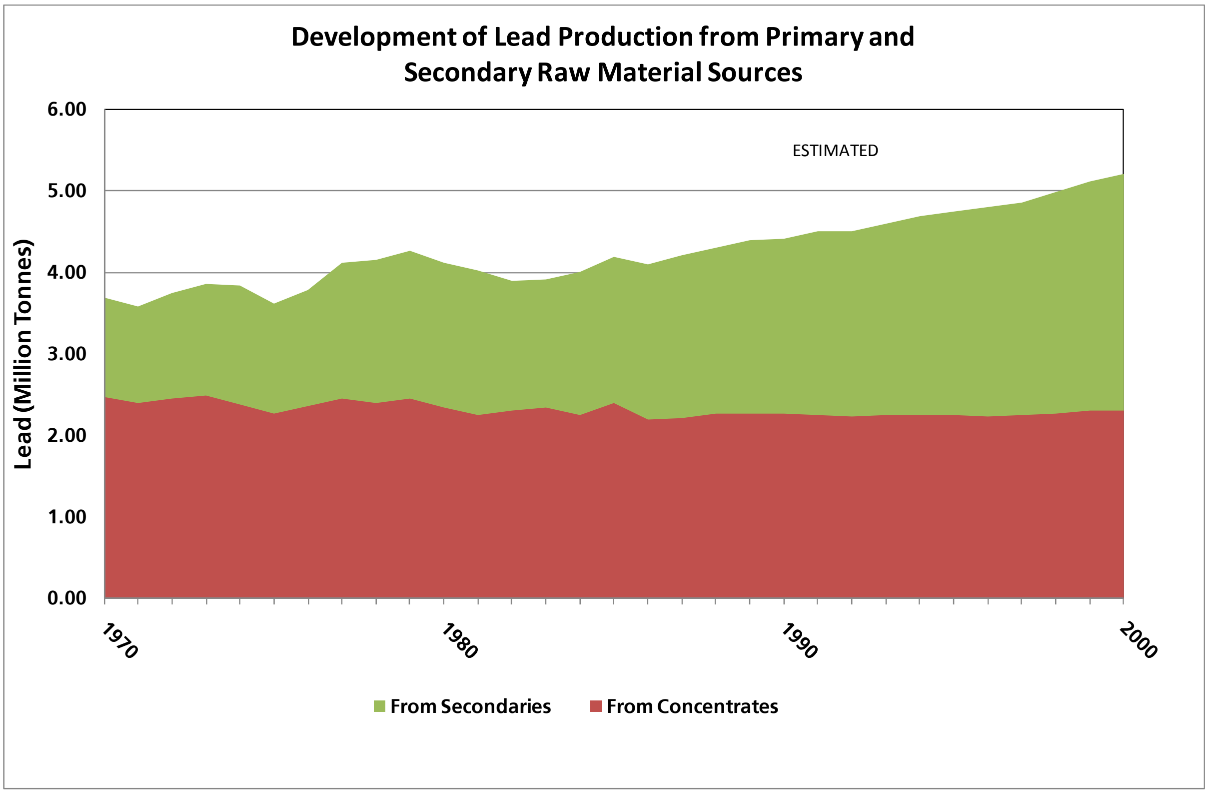

Diagram 2 Development of Lead Production from Primary and Secondary Raw Material Sources

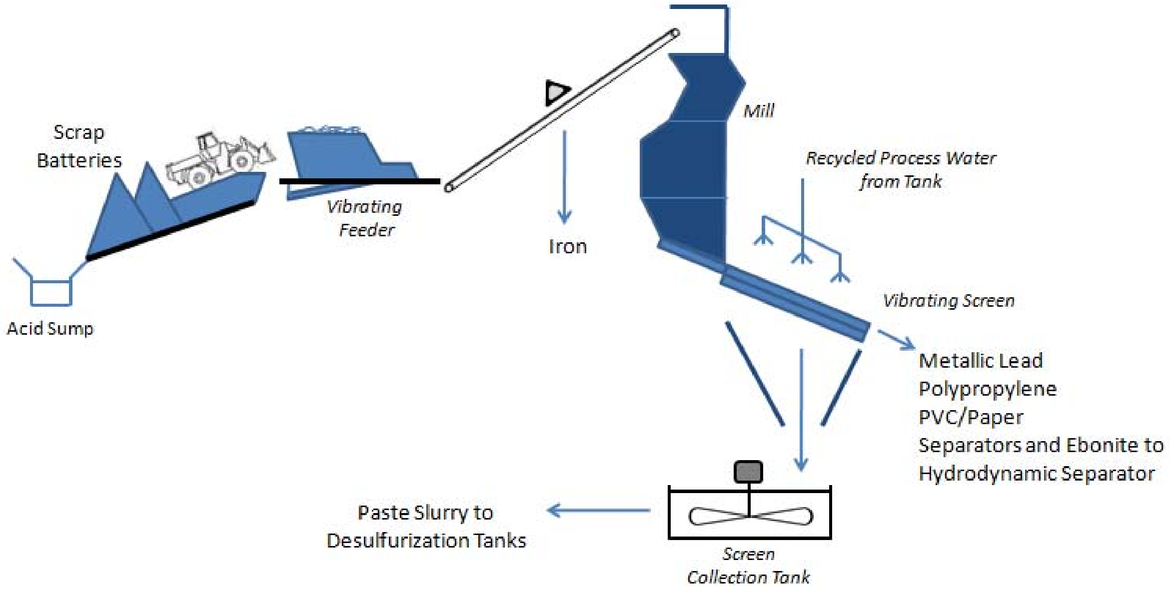

Diagram 3 Battery Crushing and Screening

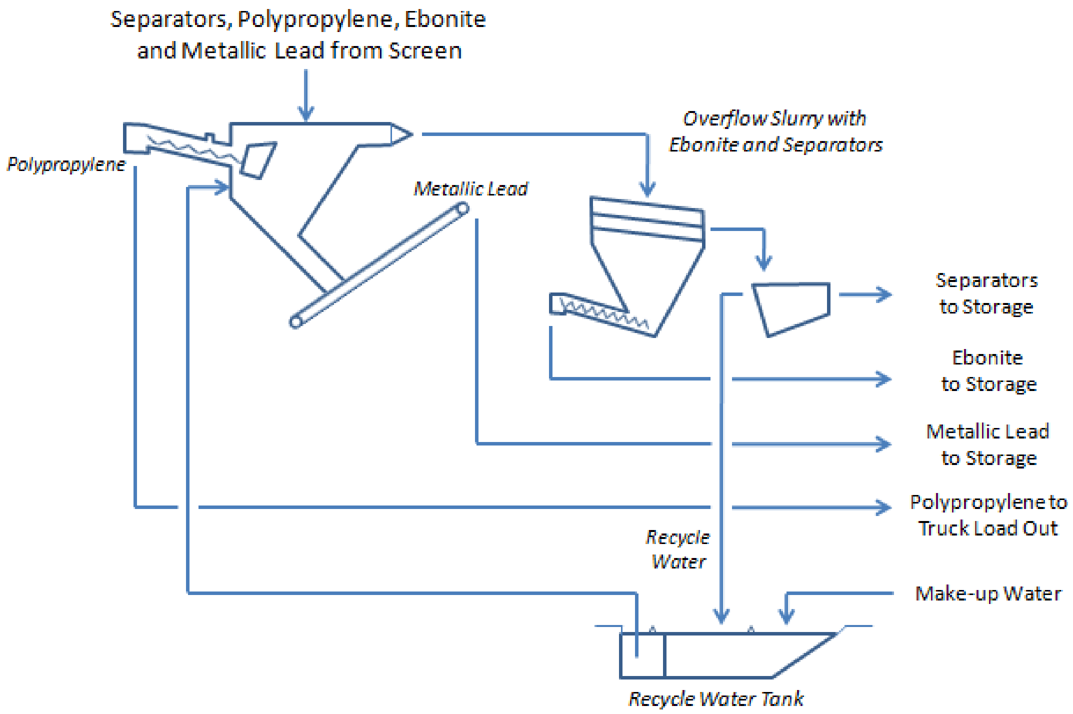

Diagram 4 Hydrodynamic Separation System

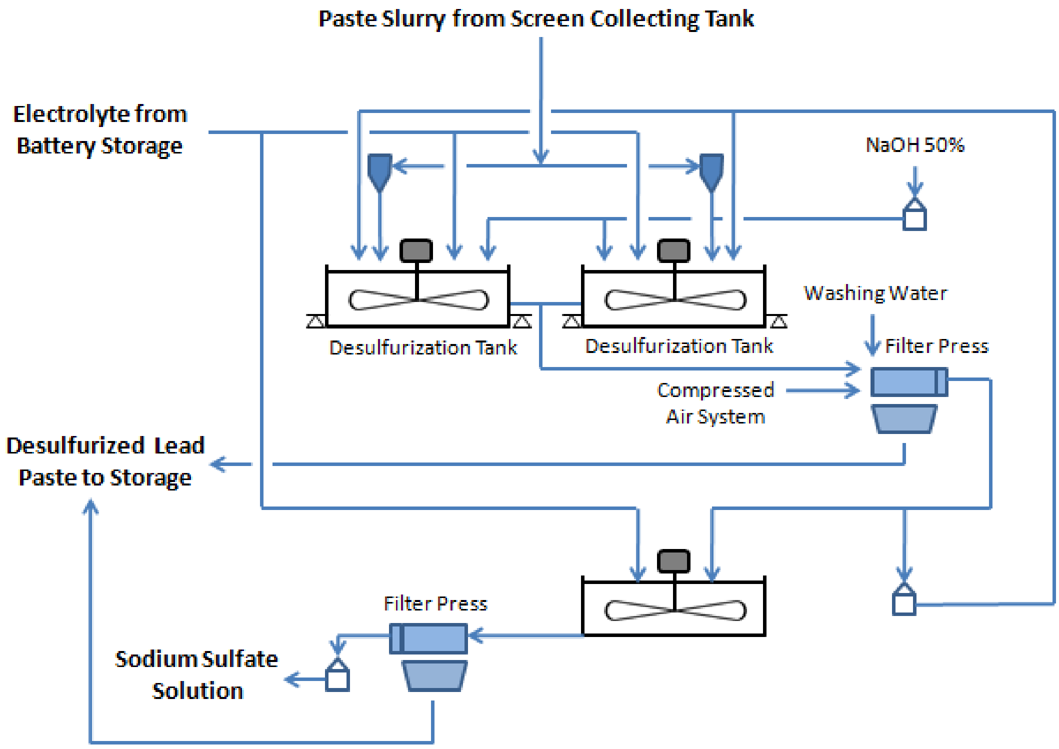

Diagram 5 Paste Desulfurization

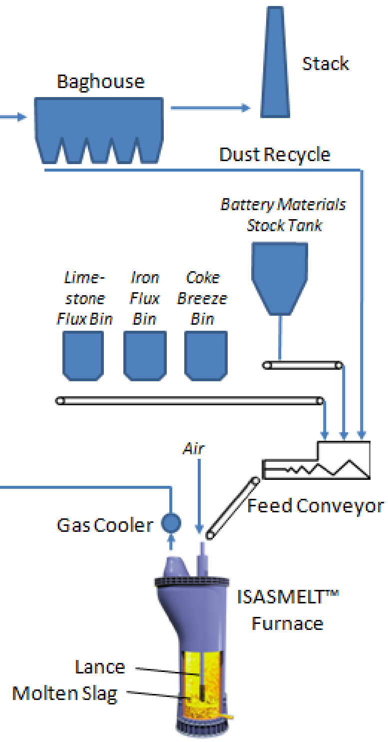

Diagram 6 Schematic Illustration of the Isasmelt Plant

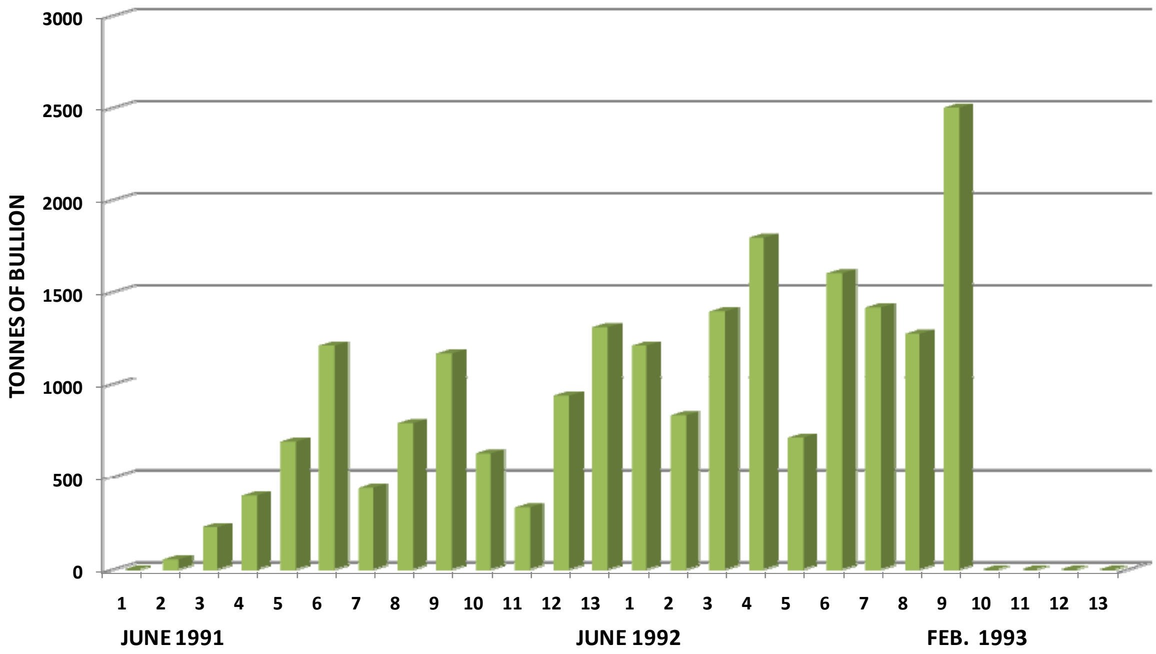

Diagram 7 Isasmelt Furnace Period Production

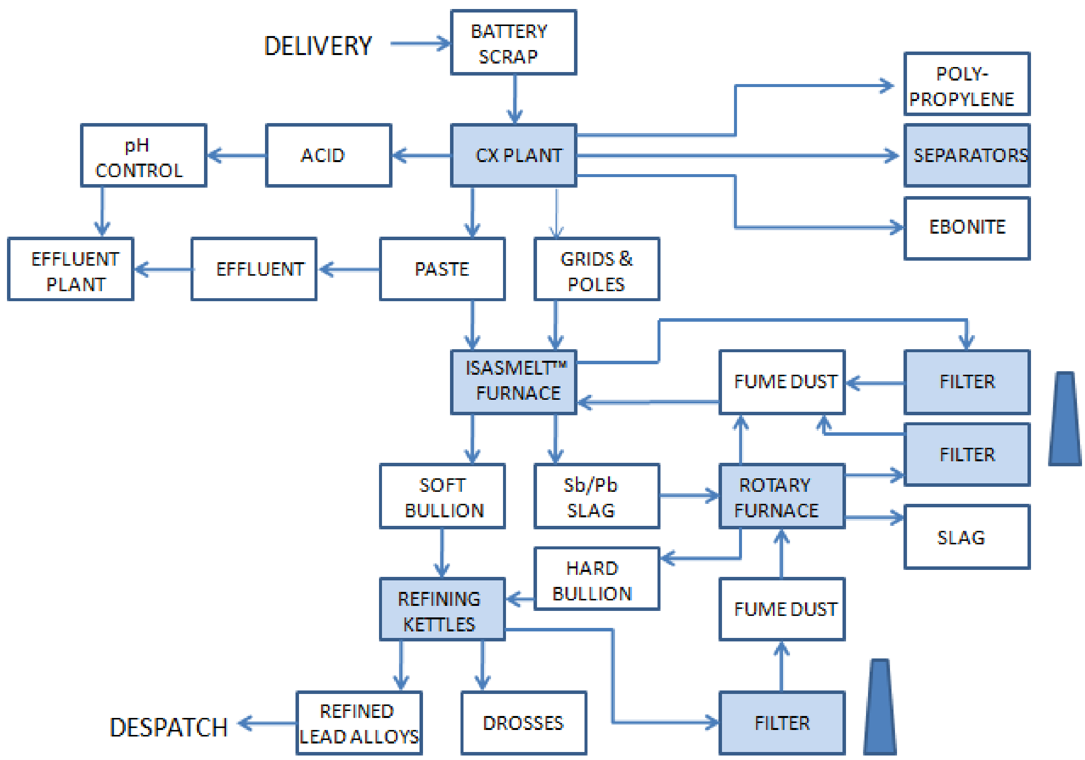

Diagram 8 Secondary Refinery Flow Sheet