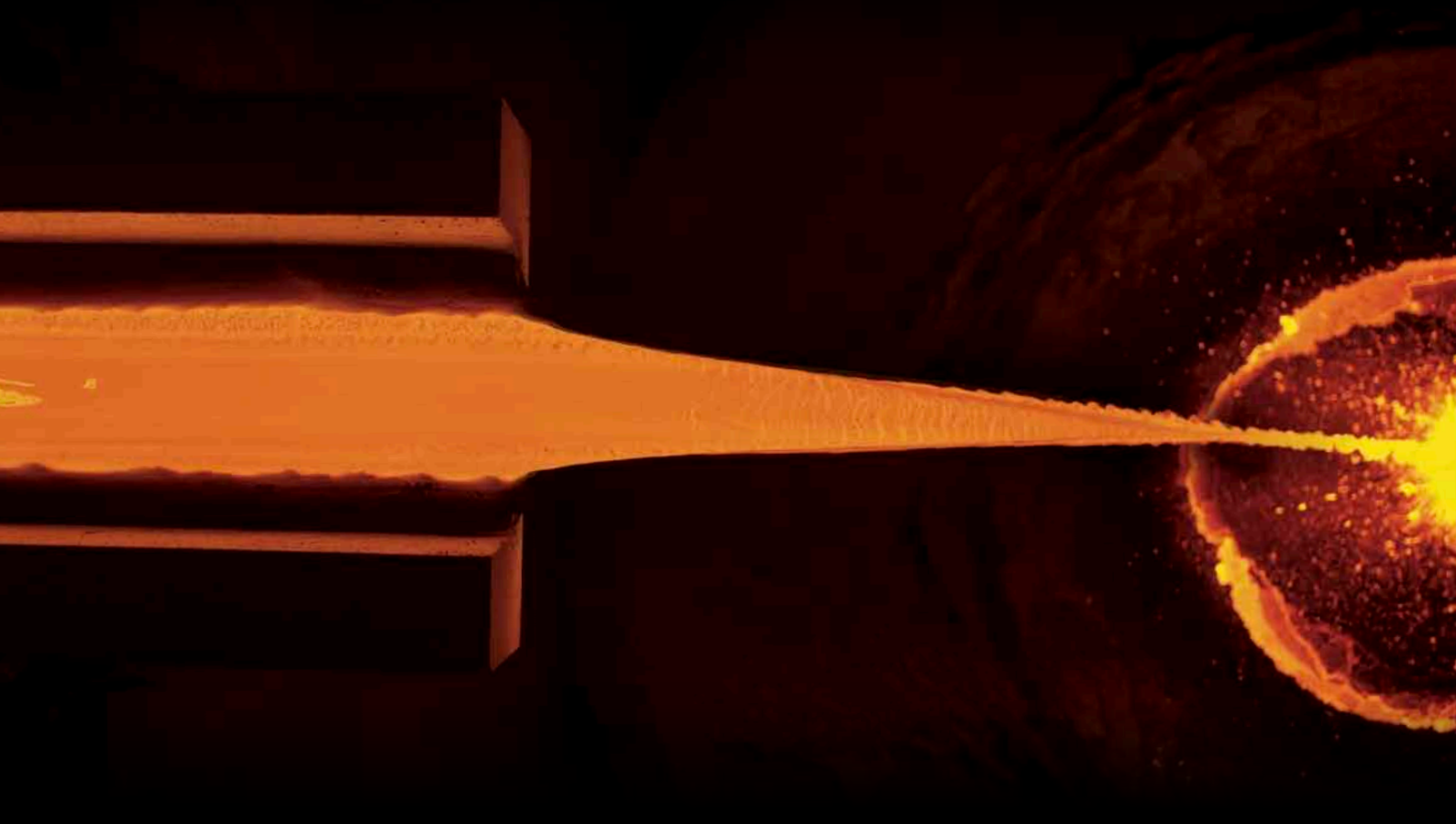


ISASMELT™

HIGH PRODUCTIVITY
CLEAN SMELTING

Proven, cost-effective
top submerged lance smelting



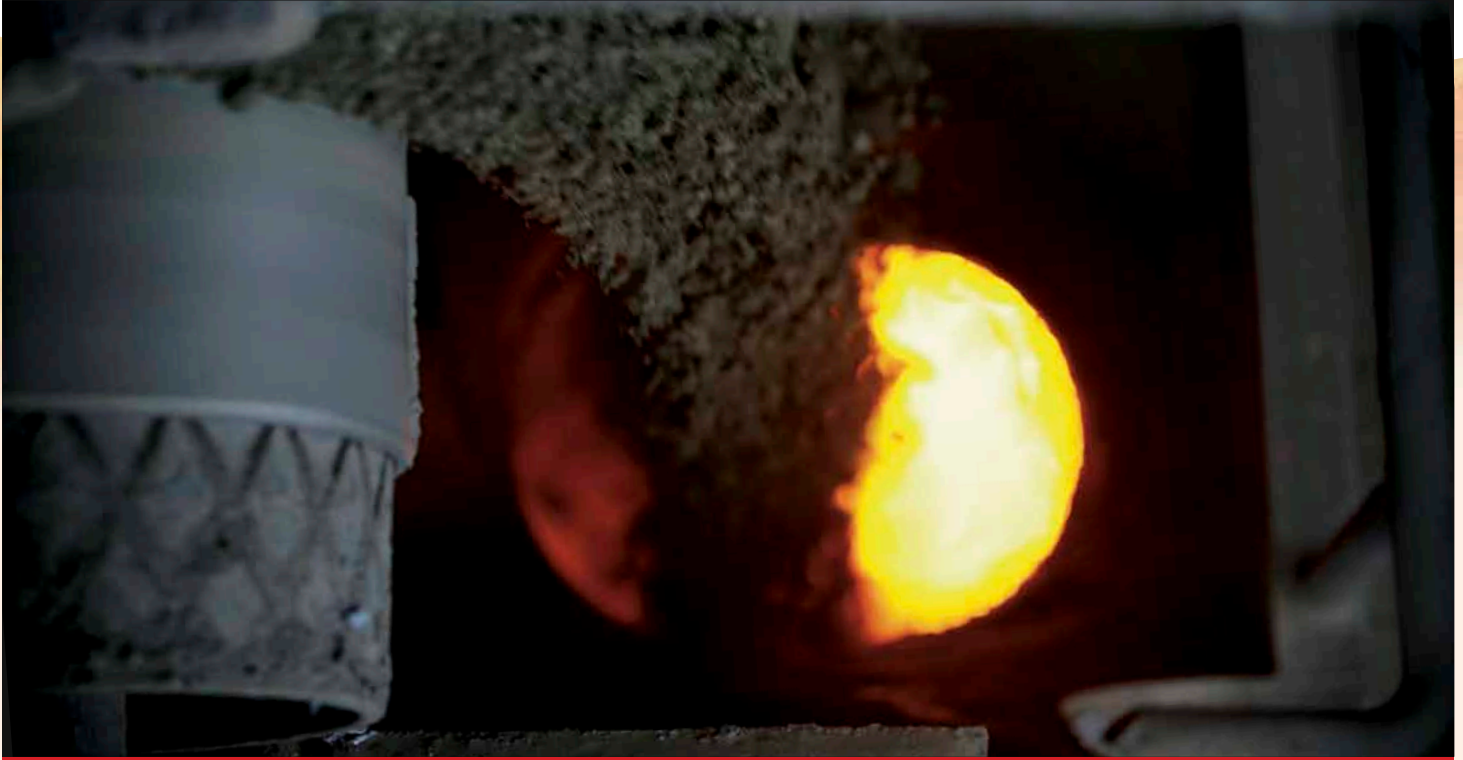
ISASMELT™


xstrata
technology



ISASMELT™

HIGH PRODUCTIVITY CLEAN SMELTING



» The ISASMELT™ process delivers clean, cost-effective, high intensity smelting using a Top Submerged Lance (TSL).

Xstrata Technology's ISASMELT™ process provides an innovative, high intensity, yet low cost submerged lance smelting process that is easy to operate. It can be used for a range of applications including primary and secondary copper smelting and copper converting, primary and secondary lead smelting, primary nickel smelting and converting, and tin, zinc and precious metals smelting.

The high intensity of the ISASMELT™ process results in high productivity from a relatively small diameter furnace. This means a small footprint, lower installation costs, straightforward maintenance and cost effective operation.

Since its introduction to the marketplace, the ISASMELT™ process has had the

highest adoption rate of any base metals smelting process.

The ISASMELT™ process is installed in countries with major lead and copper smelting and converting operations around the world, including Australia, USA, Belgium, Germany, Great Britain, India, Malaysia, China, Peru, Zambia and Kazakhstan.

In the copper industry, the ISASMELT™ process has been rapidly accepted, resulting in a transformation of the copper smelting industry. The total capacity of the installed copper ISASMELT™ plants in 2011 will be over 9,000,000 tonnes per year (t/y) of copper bearing feed materials.

The ISASMELT™ process allows new operations to reach design capacity quickly and cost-effectively and enables brownfield operations to improve profitability and meet stringent environmental standards. These operations have recognised the superior results delivered by the ISASMELT™ process

in copper and lead smelters around the world.

For new greenfield plants, the ISASMELT™ process has made entry into the mineral processing and smelting marketplace a straightforward, less expensive decision. The ISASMELT™ process requires much less up front capital than its alternatives. The innovative design, combined with Xstrata Technology's training and commissioning services means that the smelter can be rapidly commissioned to achieve design capacity at a much faster rate. For an investor in the industry this means faster time to profitability.

New operators can clearly see the innovation developed by Xstrata Technology. This innovation is not only in the equipment but also in the design and skill passed on during training, commissioning and ongoing support. This results in quick ramp up to design capacity, long refractory campaigns and low operating costs.

» ISASMELT™ ADVANTAGES

REAL OPERATING BENEFITS FOR YOUR OPERATION

HIGH PRODUCTION CAPACITY	The high intensity smelting process results in high productivity from a relatively small diameter furnace. Using a single ISASMELT™ furnace of 3.75 metres in diameter, Xstrata's own copper smelter in Mount Isa treats over 1,000,000 t/y of copper concentrate.
ENVIRONMENTALLY FRIENDLY TECHNOLOGY	ISASMELT™ technology can meet the most stringent environmental guidelines and has demonstrated virtually zero fugitive emissions, with extremely efficient offgas capture. For example, the carry-over of dust from an ISASMELT™ furnace into pollution control equipment is much lower than alternative technologies. Dust from mechanical carry-over is approximately 1% of feed weight. This results in much lower recycle of dust and lower operating and capital costs for dust capture and recirculation systems.
HIGH SPECIFIC SMELTING RATE	The ISASMELT™ lance is submerged in the slag, providing an extremely turbulent molten bath. When the raw materials enter the bath they are immediately drawn beneath the surface and react very quickly. This enables a comparatively large amount of raw material to be processed.
INNOVATIVE LOW COST FURNACE	The stationary vertical cylinder shape of the furnace allows it to be bricked easily. The furnace construction requires less maintenance than other processes, which rely on rotating furnaces, water-cooled panels and complex systems for injecting gases and solids through the walls or roof of the furnace. The lance can be removed from the furnace easily at any time if maintenance is required, with smelting continuing using a new/refurbished lance inserted from the waiting rack. Typical lance maintenance involves the replacement of the tip section of the lance.
LOW COST OPERATION	The ISASMELT™ process achieves a low total operating cost through a combination of minimal maintenance, high-energy efficiency, and low personnel requirements. Smelters utilising the ISASMELT™ process are among it the lowest-cost smelting facilities in the world.
FLEXIBLE TECHNOLOGY	The ISASMELT™ process is extremely flexible. Furnaces can be custom designed to meet the needs of the client while minimising capital cost. Lance oxygen enrichment ranges from 21% to 90%. The process has been used for primary and secondary (scrap) copper smelting, copper converting, primary and secondary lead smelting, and nickel smelting.
VERSATILE DESIGN	The ISASMELT™ TSL process can be adapted from the smallest to the largest plant throughputs. Xstrata Technology can customise the design to meet the client's varying needs in feed materials and production capacity.
HIGH VOLATILISATION OF IMPURITIES	The turbulent bath in the ISASMELT™ process ensures efficient removal of volatile elements into the offgas stream. The majority of arsenic, for example, is removed from the molten bath into the offgas stream and can be bled out of the smelting process through the offgas cleaning system.
MINIMAL FEED PREPARATION	Raw materials only need to be mixed in a drum or paddle mixer. Fine grinding and drying are unnecessary. In secondary smelting, large lumps of raw materials can be fed directly into the bath. For example, in one smelter, scrap copper up to 300 mm in length is incorporated in the continuous feed mix.
EASE OF OPERATION	A modern distributed control system is used for overall plant control. Sophisticated algorithms have been developed over the years in Xstrata's own operations to simplify control of critical process parameters. Compared to other processes, operators can learn the process quickly.
EASY STOP AND START-UP PROCEDURES	The ease of stopping and re-starting the ISASMELT™ furnace is a significant operating advantage. Typically the furnace can be stopped within 20 seconds and re-started within five minutes. Cold re-starts, due to extended shutdowns (greater than two days), are also straightforward with return to smelting typically taking less than four hours.
FLEXIBILITY IN FUEL TYPES	The ISASMELT™ process can use most types of coals, petroleum coke, coke breeze, oil (including recycled oil), propane or natural gas for fuel. An ISASMELT™ furnace can be designed to use the cheapest available fuel, and can be adapted in the future to other types should fuel costs change.
DEMONSTRATED RAPID RAMP-UP TO DESIGN CAPACITY	Xstrata Technology's complete package of detailed design, equipment supply, training and commissioning, ensures that ISASMELT™ start up is smooth, and that quick ramp-up to design capacity is achieved. Xstrata Technology's operating expertise has assisted clients to achieve design capacity within one month of start up.

»» THE ISASMELT™ PROCESS

ISASMELT™ technology is based on the use of an innovative furnace design, which is enclosed to eliminate emissions to the surrounding environment.

»» High-intensity smelting

ISASMELT™ is a high-intensity smelting process that can be used in either continuous or semi-continuous operation. It uses an extremely efficient Top Submerged Lance (TSL) technology and a stationary refractory-lined furnace. The lance tip is submerged into the bath of molten slag. Air, oxygen and fuel are fed down the lance into the molten bath, creating a highly turbulent environment that promotes very rapid reaction of raw materials.

The ISASMELT™ process can be used for a range of applications. Depending upon the application, the raw materials may consist of concentrates, metal-bearing residues, metal scrap, fluxes and solid fuel if required. These materials are typically fed on a continuous or semi-continuous basis through a port in the furnace roof.

The ability of the ISASMELT™ process to handle a wide range of feed materials, in an environmentally friendly manner, also makes it ideal for recycling applications. The Umicore and Aurubis recycling plants in Europe utilise ISASMELT™ technology in their highly successful secondary copper plants. These operations treat electronic-waste, metal bearing residues, shredder materials, copper scrap, matte, slag and dusts to produce copper, lead and tin alloys and precious metals.

»» The ISASMELT™ concept

Air, oxygen, oil/natural gas

Oil or natural gas can be injected down the lance with combustion air. Air can be enriched with oxygen.

Offgas and fume

The stationary furnace design allows efficient offgas collection and maximise offgas strength while minimising solids carryover.

Agglomerated feed

Wet, agglomerated feed can be charged directly to the furnace with no further treatment.

Patented lance design

The submerged-lance design promotes formation of a frozen slag layer on the lance tip.

Refractory-lined

Simple furnace design reduces capital cost and allows problem free, rapid refractory installation.

Frozen slag coating

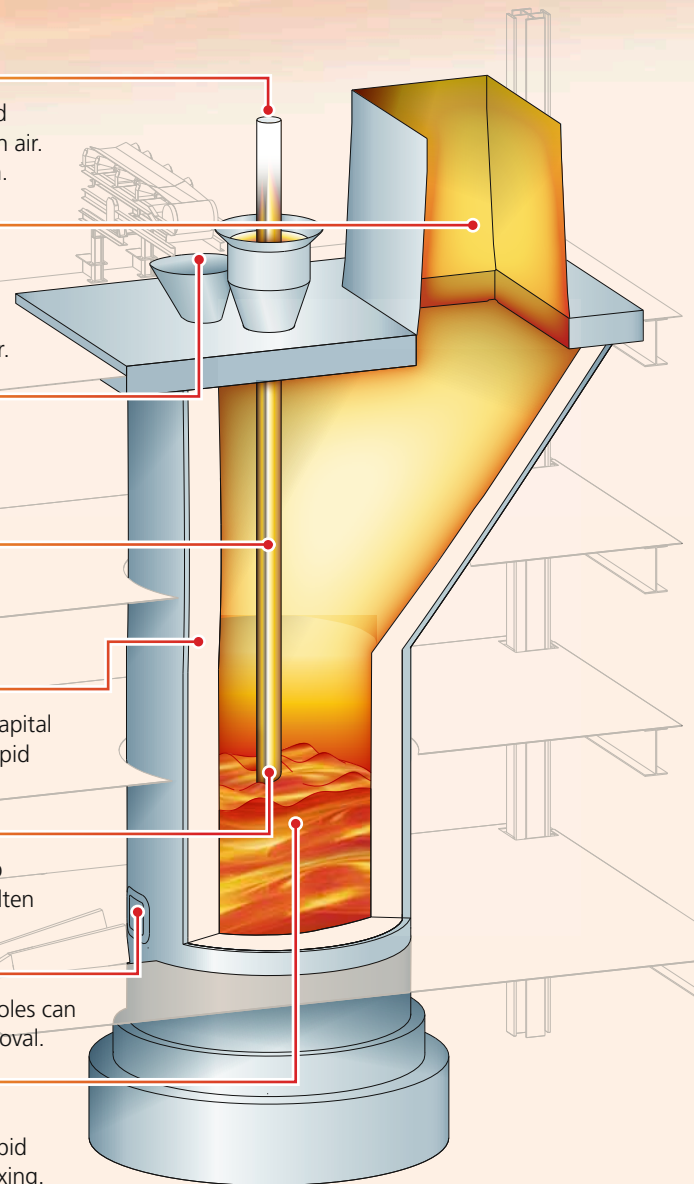
The slag coating on the lance tip protects it from wear by the molten bath.

Taphole

One or more water-cooled tapholes can be used for molten product removal.

Vigorously stirred bath

The submerged lance creates a highly agitated bath ensuring rapid chemical reactions and good mixing.



Case Study

Southern Copper Corporation (SCC)

Customer: SCC

Location: Ilo, Peru

Plant: Copper Smelter

Challenge: Reduce smelter emissions whilst keeping capital and operating expense low – against a backdrop of record low copper prices

Solution and Result: The ISASMELT™ furnace treats up to 183 t/h of copper concentrate and up to 25 t/h of copper reverts resulting in exceeding production targets and reduced operating costs. The smelter meets the new environmental regulations.

In 2003, during a period of historically low copper prices, SCC needed to modernise their smelter in order to comply with new environmental regulations defined by the Peruvian government (PAMA) for sulphur capture and particulate material emissions.

SCC needed new smelting technology to meet government emission requirements while keeping capital and operating costs low. Prior to modernisation, the operation used two reverberatory furnaces and a Teniente Converter to treat concentrate from the Toquepala and Cujone mines. Copper converting was carried out in the aisle utilising up to seven Peirce-Smith converters (PSC).

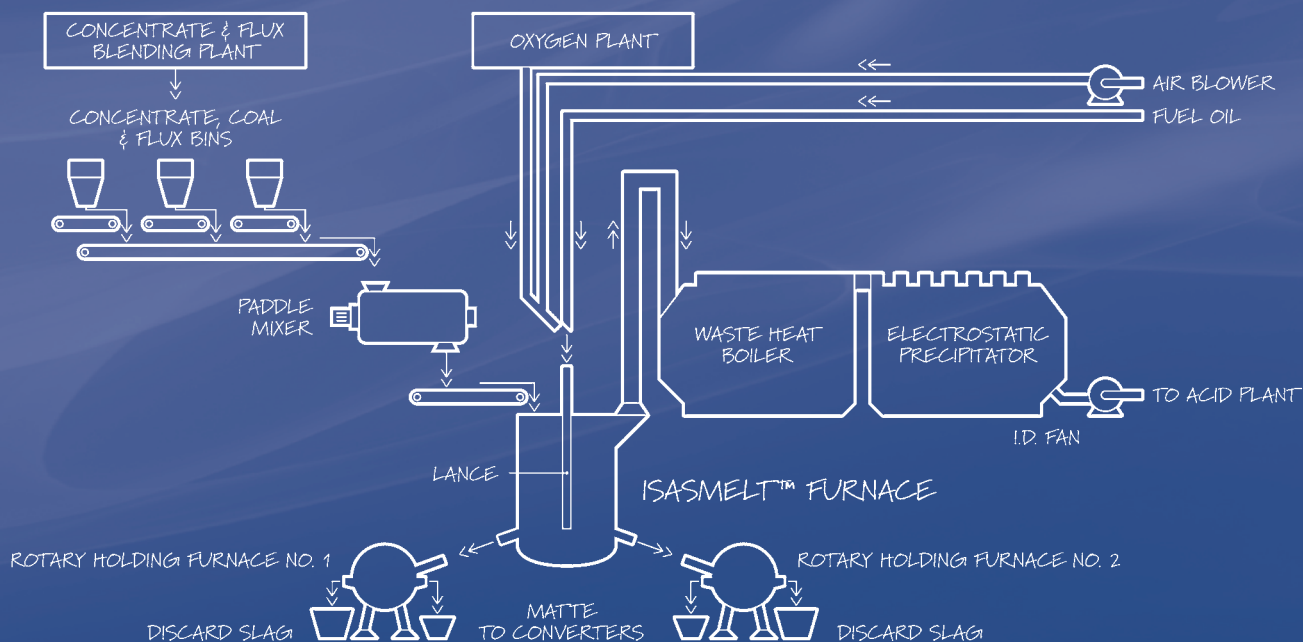
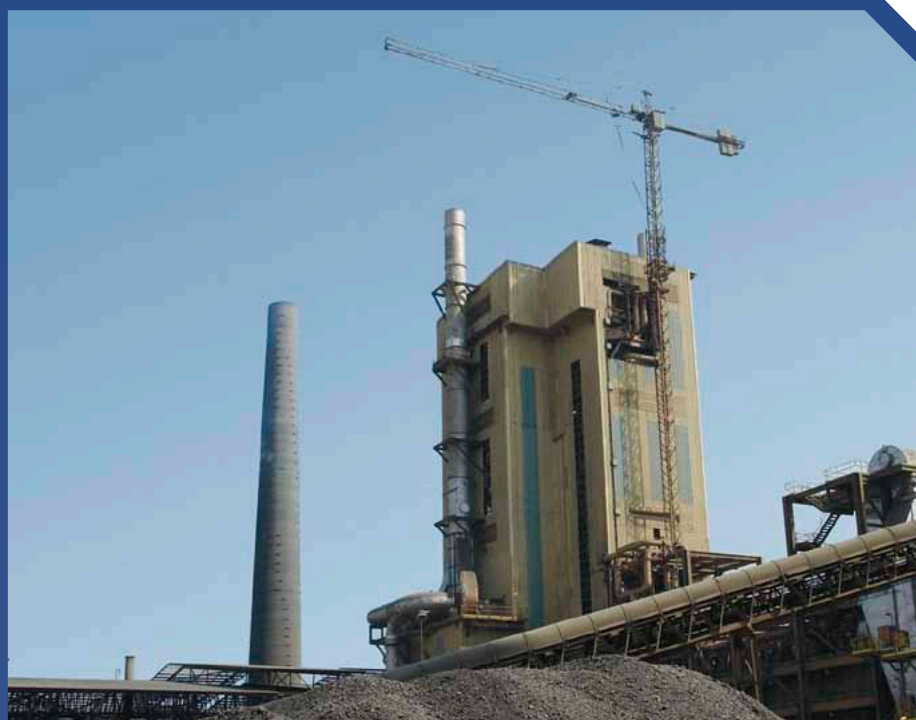
Xstrata Technology's ISASMELT™ and Rotary Holding Furnace (RHF) technologies were chosen as the core technology for processing 1,200,000 t/y of copper concentrate. The single efficient ISASMELT™ furnace replaced the reverberatory and Teniente converter furnaces.

ISASMELT™ was selected as it is proven for treating large tonnages and is substantially lower in capital and operating cost compared with other options. Xstrata Technology's scope included ISASMELT™ plant design, key equipment design, training and commissioning.

Due to the higher average matte grade of the modernised smelter, the number of PSCs was reduced from seven to four.

PSC slag or reverts are treated in the ISASMELT™ furnace. The ISASMELT™ furnace is so effective in treating this material that the aisle reverts stockpile is kept to a minimum. Up to 25 t/h of reverts can be treated in the ISASMELT™ furnace. The benefits of this are improved copper recoveries and lower copper inventories on site.

The plant has demonstrated that it will operate at design capacity of 165 dry t/h of copper concentrate and has operated up to a maximum of 183 dry t/h. The ISASMELT™ furnace produces matte consistently at target grades and the RHF produces slag that satisfies targeted copper levels.



» PROVEN TECHNOLOGY

After more than 25 years of continuous development, the ISASMELT™ design provides all licensees with clean, effective and low cost smelting.

» History

The ISASMELT™ process was developed by Mount Isa Mines (a subsidiary of Xstrata) and is based on the patented SIROSMELT lance that was invented by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia.

The first demonstration scale lead ISASMELT™ furnace was commissioned in Mount Isa, Australia, in 1983. This was followed in 1987 by a demonstration scale copper ISASMELT™. In 1991 a commercial scale 60,000 t/y ISASMELT™ primary lead smelter was commissioned at Mount Isa. This was followed by the commissioning of a 60,000 t/y nickel-copper smelter in 1991 and an 180,000 t/y ISASMELT™ copper smelter in 1992.

The success of these plants prompted further licensing to external clients. The ISASMELT™ is now in production in a variety of applications around the world. With each installation, improvements in design and operation are made and these are available to all customers.



“Tuticorin is a phenomenal asset ... It is running well at 400 kt/y capacity following the most recent shutdown ... It continues to operate in the bottom decile of the cost curve due to world class recoveries, low power consumption rates and high by-product credits ... Management are currently studying the feasibility of potentially doubling the plant size to 800 kt/y ... We would expect these initiatives to make Tuticorin the lowest cost smelter in the world.”

Pan Europe
Research

Visit 22 October 2008

» Copper/Nickel smelter installations

Year	Installation	Type	Capacity
1987	Mount Isa Mines Limited Mount Isa, Australia	Demonstration Copper Smelter	120,000 t/y copper concentrate
1991	AGIP Australia Pty Ltd. Radio Hill, Australia	Copper/Nickel Smelter	60,000 t/y concentrate
1992	Freeport McMoRan Miami Arizona, USA	Copper Smelter	700,000 t/y copper concentrate
1992	Mount Isa Mines Limited Mount Isa, Australia	Copper Smelter	1,000,000 t/y copper concentrate
1996	Vedanta Tuticorin, India	Copper Smelter	450,000 t/y copper concentrate
1997	Umicore Precious Metals Hoboken, Belgium	Secondary Copper, Lead and Precious Metals Smelter	360,000 t/y feed
2002	Aurubis Lünen, Germany	Secondary Copper Smelter	150,000 t/y feed
2002	Yunnan Copper Kunming, China	Copper Smelter	800,000 t/y copper concentrate
2005	Vedanta Tuticorin, India	Copper Smelter	1,200,000 t/y copper concentrate
2006	Mopani Copper Mines Mufulira, Zambia	Copper Smelter	650,000 t/y copper concentrate
2007	Southern Copper Corporation Ilo, Peru	Copper Smelter	1,200,000 t/y copper concentrate
2009	Yunnan Copper Chuxiong, China	Copper Smelter	500,000 t/y copper concentrate
2009	Yunnan Copper Chambishi, Zambia	Copper Smelter	350,000 t/y copper concentrate
2010	Kazzinc JSC Ust-Kamenogorsk, Kazakhstan	Copper Smelter	290,000 t/y copper concentrate
2011	Doe Run Peru La Oroya, Peru	Copper Smelter	280,000 t/y copper concentrate
2011	Vedanta Tuticorin, India	Copper Smelter	1,360,000 t/y concentrate
2011	Yunnan Copper Liangshan, China	Copper Smelter	500,000 t/y concentrate

» Lead smelter installations

Year	Owner	Type	Capacity
1983	Mount Isa Mines Limited Mount Isa, Australia	Demonstration Lead Smelter	5–10 t/hr concentrate
1985	Mount Isa Mines Limited Mount Isa, Australia	Demo Lead Slag Reduction and Dross Treatment	5 t/hr lead slag
1991	Mount Isa Mines Limited Mount Isa, Australia	Primary Lead Smelter	60,000 t/y lead metal
1991	Britannia Refined Metals Northfleet, UK	Secondary Lead Smelter	30,000 t/y lead metal
2000	Metal Reclamation Industries Pulau Indah, Malaysia	Secondary Lead Smelter	40,000 t/y lead metal
2005	Yunnan Metallurgical Group Qujing, China	Lead Smelter	160,000 t/y lead concentrate
2011	Kazzinc JSC Ust-Kamenogorsk, Kazakhstan	Lead Smelter	216,000 t/y lead concentrate
2011	Yunnan Metallurgical Group Huize, China	Lead Smelter	160,000 t/y lead concentrate

About Xstrata Technology

Xstrata Technology Pty Ltd is a wholly owned subsidiary of Xstrata PLC, a diversified international mining company. The company's world-class operations use the latest technologies to create shareholder value.

Headquartered in Zug, Switzerland, Xstrata's businesses maintain a meaningful position in seven major international commodity markets: copper, coking coal, thermal coal, ferrochrome, nickel, vanadium and zinc, with a growing platinum group metals business, additional exposures to gold, cobalt, lead and silver, recycling facilities and a suite of global technology products, many of which are industry leaders. The Group's operations and projects span 19 countries.

In addition to these commodity markets, an integral part of the Xstrata group of operations is their process technology capabilities.

Xstrata has a long record of developing processing technologies for in-house use and for sale to external clients. The company develops and markets key strategic technologies, both as a means of maintaining technical leadership and as a technology marketing business. These technologies encompass a large part of the processing route and are developed, tested and marketed around the world by Xstrata Technology.

Our technologies have a demonstrated track record with project success, low capital and operating costs and superior environmental performance.



Case Study

Urban Mining and Recycling in the 21st Century

The Umicore Precious Metals plant at Hoboken, Belgium, has successfully used the ISASMELT™ technology for a new, modern process to treat complex materials.

Customer: UMICORE

Location: Hoboken, Belgium

Plant: Secondary Smelter treating copper, lead and precious metals feed

Challenge: Meet EU environmental regulations while building the Hoboken site into a world class materials processing facility using the best available technology

Solution & Result: ISASMELT™ installed as part of an integrated smelting and refining facility; reduced lead emissions by 97%



© Umicore, 2010



© Umicore, 2010

An important strength of the ISASMELT™ technology has been its capacity and versatility to be incorporated into innovative applications. The Umicore Precious Metals smelter at Hoboken, Belgium, is an example of how ISASMELT™ can be used to prosper in an increasingly difficult industry. Being located on the edge of a major European city, tightening environmental regulations required a breakthrough – that is, development of a novel process to treat complex materials whilst improving environmental performance. ISASMELT™ technology was the solution.

Umicore transformed its operation from a primary smelter to an integrated smelting and refining facility that recovers a wide range of metals by recycling complex materials containing precious metals.

The Umicore team challenged their existing business and found new ways to remain competitive. Using the ISASMELT™ process, Umicore moved into the business of ‘urban’ mining, creating value by recycling waste materials such as electronic waste, dusts, metal bearing residues, scrap metal and matte.

Umicore needed a flexible smelting technology that would form the core of the new recycling complex. After reviewing many options, Umicore collaborated with Mount Isa Mines (now Xstrata) to develop a new application of the ISASMELT™ technology.

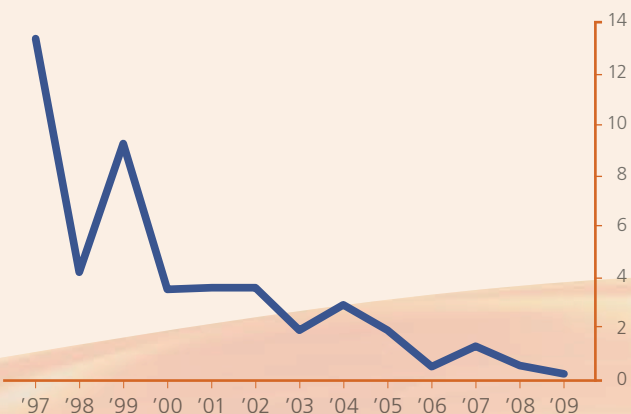
Following successful pilot plant work and subsequent demonstration plant work, a full-scale commercial ISASMELT™ furnace was commissioned at the end of 1997. It is now treating up to 360,000 t/y of secondary feed materials.

Precious Metals and Base Metals Process

Complex lead/copper materials, containing valuable minor elements are treated in the ISASMELT™ furnace in a two-step smelting and converting process to produce up to 17 different metals, including copper, lead, tin and precious metals.

The smelting stage involves the oxidation of the feed to form a copper matte and a smelting slag by injection of oxygen enriched air through the lance. The silica-

Guided (stack) lead emissions – t/y



97%
reduction

Lead emissions from guided (stack) sources were reduced from 13.283 t/y in 1997 to 0.307 t/y in 2009.

Diffuse (fugitive) lead emissions – t/y



84%
reduction

Lead emissions from diffuse (fugitive) sources were reduced from 9.426 t/y in 1997 to 1.492 t/y in 2009.

Element	Limit value	2009
	ng/m ³	ng/m ³
Lead	500	170
Cadmium	30	4

Table 1:

VMM Recorded levels of metals in PM₁₀ 200 metres north of the smelter

based, lead-rich slag produced during smelting is tapped and the remaining copper matte is converted to blister copper using the same ISASMELT™ furnace. The precious metals are captured into the copper phase for further processing.

The ISASMELT™ furnace operates in two very different environments – low oxygen partial pressure during smelting and high oxygen partial pressure during converting. The different oxygen partial pressure conditions provide a harsh test for the refractory. Even in these extreme operational conditions, the ISASMELT™ furnace achieves a good campaign life.

Hoboken Environmental Performance

Metal content in PM₁₀ (particulate matter less than or equal to 10 micrometres) is an important parameter in the evaluation

of the environmental performance at Hoboken.

Table 1 shows the recorded concentration levels of metals in PM₁₀ measured by the Flemish Environmental Agency (VMM) 200m north of the smelter, in the prevailing wind direction.

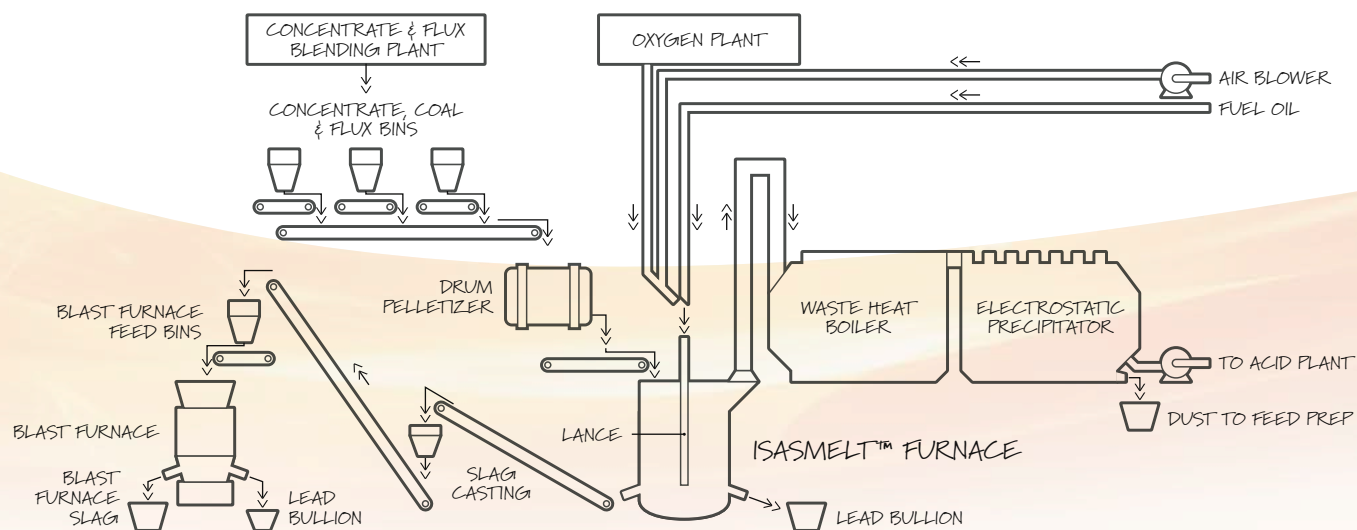
The implementation of the ISASMELT™ process at the heart of the modern and environmentally friendly metallurgical complex at Hoboken has allowed Umicore to operate within the demanding requirements of EU environmental regulations. Umicore have drastically reduced guided (stack) and diffuse (fugitive) emissions to the atmosphere, while transforming the operation into one of the new benchmarks for the global metal processing industry.



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Case Study

A better flow sheet for lead smelting



Customer: Yunnan Metallurgical Group

Location: Qujing, China

Plant: Primary lead and zinc smelter

Challenge: Achieve high productivity, and improve environmental performance

Solution and Result: The net result is a highly energy efficient process for the production of lead, with optimal gas capture

The patented process using ISASMELT™–Blast Furnace technology has been in operation at the Yunnan Metallurgical Group's (YMG) Qujing smelter in China since 2005. The ISASMELT™ TSL smelting technology provides a high intensity

environment for the production of lead bullion and lead silicate slag. The slag is subsequently reduced in the Blast Furnace to produce lead bullion.

YMG had a vision to build a large lead and zinc complex with high productivity and world-class environmental performance. They approached the ISASMELT™ team to develop a new process. The production of sinter and use of the blast furnace is the traditional and most common method of smelting lead concentrate. Traditional sinter machine technology has weaknesses such as the huge recycle of hot materials, the difficulty of eliminating emissions, and the low sulphur dioxide concentration in the off gas making acid plant operation difficult.

The other difficulty facing YMG was that they needed to treat a significant proportion of zinc leach residues from the zinc plant. The ISASMELT™–Blast Furnace technology is able to effectively treat the lead concentrates and zinc leach residues whilst producing an off gas with optimal sulphur dioxide concentration for easy conversion to sulphuric acid. Other benefits of the ISASMELT™ technology such as innovative low cost furnace, minimal feed preparation and ease of operation were factors in YMG's choice of the ISASMELT™–Blast Furnace technology over competing lead smelting technologies.

ISASMELT™ and Blast Furnace – The Best of Both Worlds.

In this process, lead concentrate is fed into the ISASMELT™, which produces a high lead slag, lead bullion, and offgas. Importantly, the low-volume offgas produced by the ISASMELT™ furnace contains a high concentration of SO₂, which is suitable for sulphuric acid manufacture.

The slag that is produced in the ISASMELT™ furnace is tapped from the furnace and then cast, solidified, and crushed, if required, to enable optimum feed sizing to the blast furnace. It can be stockpiled before being fed to the blast furnace, or can be fed directly to the furnace.

The de-coupling of the ISASMELT™ and blast furnace allows each furnace to operate at its optimal efficiency and allows maintenance to be performed on either furnace while the other is still operational.

The success of the ISASMELT™–Blast Furnace process has resulted in YMG (through its subsidiary Yunnan Chihong Zn and Ge Co. Ltd) choosing this process for its Huize lead smelter project in Yunnan Province. The new greenfield smelter will combine an ISASMELT™ furnace with a blast furnace to smelt lead concentrates and zinc leach plant residues.



CUSTOM SOLUTIONS

Tailored solutions and close co-operation ensure optimal results.



» Proven solutions

Xstrata Technology's highly experienced team of engineers, metallurgists and operators work closely with our customers' teams to ensure the optimal technical solution is designed for your needs.

The Xstrata Technology project team can provide support to the customer along every step of the project, including: regular project meetings; site visits during the design phases; construction supervision; hands-on training in an operating smelter; specialist support during proprietary equipment installation and commissioning and advice on how to optimise plant performance following start-up.

Xstrata Technology provides ongoing support to licensees following commissioning. We encourage frequent interaction between our own team and those of the clients, as well as interaction between client teams.

» Technology partnership

Xstrata is a committed user of the ISASMELT™ technology.

Xstrata has a vested interest in developing and providing world-class technical resources, which benefit its own operations. Xstrata Technology makes these resources available to all users of the ISASMELT™ process through the Technology Partnership.

The Technology Partnership offers licensees a package that is much more than the supply of key designs and equipment. The package combines Xstrata's many years of operational experience with the latest developments in technology, delivering rapid and successful transfer of the ISASMELT™ process to clients and sustaining efficient operation into the future.

By implementing the ISASMELT™ process, clients have access to a technical exchange program that encapsulates the experiences, improvements and developments of other technology users.

We hold regular licensee workshops, hosted by ISASMELT™ customers, during

which technical personnel from smelters all around the world gather to compare operating techniques and discuss how to improve their profitability further.

Xstrata Technology also provides ongoing support to licensees following commissioning. We encourage frequent interaction between our own team and those of the clients, as well as interaction between client teams.

Range of services

Xstrata Technology is backed by a world class engineering design team utilising advanced process modelling, engineering design packages and project management systems to enable all aspects of the client's projects to be met on time and within budget. Xstrata Technology offers a range of services that are customised to meet clients' needs. This includes; feasibility studies; pilot plant testing; engineering design; supply of specialised equipment and spares; process and operational training; commissioning assistance and plant optimisation assistance.



Xstrata operates mines and smelters throughout the world.
Tough testing grounds that make our process technologies the best on earth.

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