International Stainless Steel Forum 2011 Sustainability Award

Case Studies

SUSTAINABLE
STAINLESS

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Welcome from the Chairman

Achieving the long-term economic, social and environmental sustainability of the stainless steel industry is one of the key goals for the International Stainless Steel Forum (ISSF) and our member companies.

One way of achieving this is by sharing best practices from across the industry so that we can all learn, and take meaningful actions that improve our sustainability performance. To facilitate this process, ISSF has launched the inaugural Sustainability Award which will be presented to a member company during ISSF-15 in Madrid during May 2011.

This booklet contains the seventeen case studies that have been submitted for the Award. The examples come from eleven member companies who have operations around the world. All of the case studies are deserving of the award and I would like to thank each of the members who have entered.

The case studies cover all aspects of sustainability. Efforts to reduce greenhouse gases and improve the use of by-products show our commitment to the environment. Actions to improve safety in the workplace demonstrate the resolve of members to ensure a safe working environment for our employees, vital to ensure the social sustainability of the industry. Investments in new processes and procedures add value to our businesses, ensuring their long-term economic sustainability.

We hope that many businesses, both inside and outside the stainless steel value chain, will find inspiration in the examples featured in this booklet. They aptly demonstrate the innovative thinking that is required to ensure the sustainability of our world for future generations.

David Martin

Chairman, ISSF Health and Environment Committee

Secretary General's Message

The stainless steel industry produces one of the most sustainable products known to mankind. Durability is a hallmark of stainless steel and, at the end of its long life, a stainless product can be recycled without losing its properties.

Stainless offers sustainable solutions in many different markets and applications. When in use, stainless steel applications are hard-wearing and need little maintenance, making them cost-effective solutions. At the end of life, they are easily collected and recycled to produce stainless steel again.

Stainless steel products are also hygienic and neutral to people, a fact that sees them widely used in medical applications.

Sustainability has been recognised by the stainless steel industry as one of its major challenges for the future. Progress has been made on reducing the industry's carbon footprint. An increase in the rate of recycling and process improvements across the stainless supply chain are just some of the actions that have been taken. However, it is clear that more needs to be done.

This brochure presents just some of the actions that the world's stainless industry is taking to improve our environmental, social and economic performance. By taking these actions, and finding new ways to improve our sustainability, we will ensure the stainless industry lasts at least as long as our products!

When it comes to sustainability, stainless steel is not the problem..., but it is part of the solution.

Pascal Payet-Gaspard

ISSF Secretary General

What Makes Stainless Steel a Sustainable Material?

Before we can determine whether stainless steel is a sustainable material, we should first define what we mean by sustainability in relation to what is known as the triple bottom line: People, Planet and Profit.

People

The material, in its use or in its production process, respects the human being, especially in terms of health and safety. A sustainable material does not harm the people working to produce it, or the people who handle it during its use, recycling and ultimate disposal.

Stainless steel is not harmful to people during either its production or use. A protective layer forms naturally on all stainless steels because of the inclusion of chromium. The passive layer protects the steel from corrosion – ensuring a long life. As long as the correct grade of stainless is selected for an application, the steel remains inert and harmless to the people who handle it and the environment.

These characteristics have made stainless steel the primary material in medical, food processing, household and catering applications.

Planet

The emission footprints of the material, especially those related to carbon, water and air, are minimised. Reuse and recyclability are at high levels. The material has low maintenance costs and a long life, both key indicators that the impact of the material on the planet is at the lowest levels possible.

The electric arc furnace (EAF), the main process used to make stainless steels, is extremely efficient. An EAF has a low impact on the environment in terms of both CO_2 and other emissions. The EAF is also extremely efficient at processing scrap stainless, ensuring that new stainless steel has an average recycled content of more than 60%.

Stainless steels are easily recycled to produce more stainless steels and this process can be carried on indefinitely. It is estimated that about 80% of stainless steels are recycled at the end of their life. As stainless steel has a high intrinsic value, it is collected and recycled without any economic incentives from the public purse.

Profit

The industries producing the material show long-term sustainability and growth, provide excellent reliability and quality for their customers, and ensure a solid and reliable supply-chain to the end consumer.

Choosing stainless steel for an application ensures that it will have low maintenance costs, a long life and be easy to recycle at the end of that life. This makes stainless an economical choice in consumer durables (such as refrigerators and washing machines) and in capital goods applications (such as transportation, chemical and process applications).

Stainless steels also have better mechanical properties than most metals. Its fire and corrosion resistance make stainless a good choice in transportation, building or public works such as railways, subways, tunnels and bridges. These properties, together with stainless steels' mechanical behaviour, are of prime importance in these applications to ensure human beings are protected and maintenance costs are kept low.

Stainless also has an aesthetically pleasing appearance, making it the material of choice in demanding architectural and design projects.

Taking into account its recyclability, reuse, long life, low maintenance and product safety, the emissions from the production and use of stainless steels are minimal when compared to any other alternative material. A detailed and precise analysis of the sustainability of stainless steel makes the choice of stainless a logical one. This might explain why, as society and governments are becoming more conscious of environmental and economic factors, the growth in the use of stainless steel has been the highest of any material in the world.

Summary of Case Studies

All ISSF member companies were invited to submit entries for the inaugural Sustainability Award. Seventeen entries were received in total from eleven companies. These members operate stainless steel plants in Africa, Asia, Europe, and South America.

Members were asked to select a category that best described their entry. In many cases, multiple categories were selected.

The following table summarises the entries that were received. Note that EMS stands for Environmental Management Systems.

	Company	**Case Study**	*Employee Training*	*Energy Intensity*	*EMS*	*Greenhouse Gas Emissions*	*Material Efficiency*	*New Processes and Products*	*Safety*
01	Acerinox	Safety and Environment Awards	■						
02		Improving the Placement of Refractory Bricks	■						■
03	Aperam	Charcoal: an Intelligent Solution to Reduce CO_2 Emissions				■			
04		Transforming Residues into By-products					■		
05	Columbus	Water Recycling					■		
06	JSL	Resource Conservation and Pollution Control		■	■		■		
07	NMI	Fully Integrated Site Design		■	■	■	■	■	
08	NSSC	Using a Rotary Hearth Furnace to Recover Valuable Metals					■		
09	Outokumpu	Opencell™ Sandwich Panel Structure						■	
10		Reducing Waste to Landfill					■		
11		Long-term Energy Efficiency and CO2 Improvements		■		■			
12		Assessing the Long-term Effects of Exposure to Metals							■
13	POSCO	Recycling AOD-slag					■	■	
14		Creating FeNi Pellets from Industrial Waste					■	■	
15	Sumitomo	New Stainless Steel Boiler Tubes for USC Power Generation				■			
16	TK Nirosta	Improving Corporate Safety Culture	■						■
17	YUSCO	Improving Energy Efficiency and Reducing Greenhouse Gases				■			

01

Acerinox S.A.

Safety and Environment Awards

Employee Training

Challenge

Acerinox wanted to involve every worker in safety and environmental issues.

Action

The creation of the Safety and Environment Awards by Acerinox was the perfect way to involve employees in the action. Every employee had the opportunity to present an idea that would improve the safety or environmental conditions at the site. Each award winner receives a financial prize.

Three prizes are awarded for safety and another three for environmental improvement ideas. A committee evaluates the proposals and selects the winners.

Outcome

Acerinox has received a positive reaction from staff, and each year many proposals are submitted for the Safety and Environment Awards. Some of the ideas presented have already been implemented and are bringing benefits for Acerinox, and our safety and environmental performance.

02

Acerinox S.A.

Improving the Placement of Refractory Bricks

Employee Training Safety

Challenge

After analysing accident statistical reports, Acerinox's Accident Prevention Service detected a high number of lost time injuries caused by musculoskeletal injuries in the Refractory section. The Prevention Service decided to analyse the section's work conditions, particularly during the placement of refractory bricks in ladles and argon oxygen decarburisation (AOD) converters.

Action

Technical Safety staff carried out an ergonomic study of the placement of refractory bricks.

The study looked in detail at the placement process including the type of bricks, weight, and work posture and movements required to do the work. They then evaluated the manual handling and ergonomic conditions of the work.

The evaluation of work conditions utilised the specifications in the National Work Hygiene and Safety Institute's (INSHT) technical guide.

Outcome

The study concluded that the following corrective measures should be implemented:

- Installation of new equipment to place the bricks.
- Acquisition of new work tables so bricks can be placed at different heights.
- Delivery of a specific Manual Handling training course to staff.

The implementation of these actions has resulted in a considerable decrease in the number of lost time injuries in the Refractory section.

An investigative project has also been started to identify if a robot could be designed to place the bricks.

03

Aperam

Charcoal: an Intelligent Solution to Reduce CO_2 Emissions in the Steel Industry

Greenhouse Gas Emissions

Challenge

In 2010, global steel production reached 1.4 billion tonnes. This means that the steel industry emitted around two billion tonnes of CO_2 during the year. Minimising CO_2 emissions in steel production is essential to enable mankind to move towards a more sustainable future.

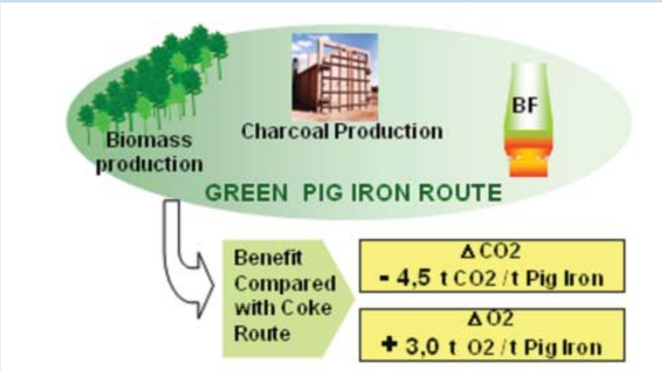
Ironmaking, using blast furnace technology, accounts for more than 90% of the CO_2 emissions in steel production. However, utilising charcoal as a thermal reducing agent in the blast furnace can substantially reduce CO_2 emissions, even considering the CO_2 emitted during the life cycle of the charcoal – from the tree growing in a forest through to charcoal consumption.

The challenge for Aperam was to convert Blast Furnace 2 (BF2) at our Timóteo (Brazil) plant from coke to charcoal. Among other benefits, our goal was reduce CO_2 emissions by around 700,000 tonnes per year.

Once Aperam begins to produce pig iron in BF2 using charcoal, the company will have established a much more sustainable steel production route which is environmentally responsible, socially fair and economically feasible: the Green Route.

Part of the benefit of using charcoal is not covered by the rules of the Kyoto Protocol. Benefits not covered include:

- A reduction in methane emissions at carbonisation of around 200 Kt CO_2/year)
- A reduction in CO_2 emissions at BF2 of 500 Kt CO_2/year).



Theoretical CO_2 and O_2 Balance in Pig Iron Production

Action

The following actions were taken to convert BF2 at Timóteo to use charcoal:

- Improve the technology to enable charcoal to be utilised in a blast furnace.
- Develop the charcoal production process, ensuring all stages of the process are sustainable according to the following criteria:
    1. Ensure each process is environmentally and socially correct, as recognised by an international entity.
    2. Ensure our charcoal could be produced so that it is price competitive with coke at any level. This required an increase in productivity and a reduction of production costs from planting to carbonisation.
    3. Be ready to meet all the charcoal consumption demanded by BF2.

Outcome

The use of charcoal in our blast furnaces has reached a benchmark for this type of process. Developments made in the past ten years lead us to expect impressive reductions in greenhouse gas emissions through the use of charcoal in Blast Furnace 2. The reduction of emissions during production is expected to reach 10%, while consumption of carbon is expected to drop 5%.

Over the last 30 years, Aperam has developed several genetically modified eucalyptus clones and technology to manage a eucalyptus forest. Today, Aperam has one of the most important inventories of eucalyptus genetic material in Brazil. The species developed by Aperam have high productivity, resist disease well and have good drying resistance. This has contributed greatly to advances in forest productivity and wood quality.

Soil preparation is accomplished without the use of forest burning, a practice which is very harmful to the forest ecosystem. Intensive mechanization of processes such as soil preparation, planting, forest harvest and wood preparation has been achieved.

New kiln technology (RAC 700) has been developed and is considered a breakthrough in carbonisation technology. Using kilns with 700 m^3 wood and gas burning capacity enables productivity to be improved and eliminates CH_4 emissions in the process.

Several actions have been taken to ensure Aperam contributes to the integrated and sustainable development of the communities where our charcoal operations are located. Important social programmes have been developed by the Aperam Acesita Foundation in partnership with local institutions. These programmes cover education, health and life quality for the population.

Part of the forest area has been set aside as a permanent ecological reserve. In 2007 the company was certified by Forest Stewardship Council (FSC).

In order to supply all of the charcoal needed for BF2, Aperam started to plant new eucalyptus forest, aiming to produce an additional 300,000 tonnes of charcoal per year. In 2009, the Board authorised the investments required to convert BF2 to charcoal and the construction of the carbonisation kilns.

BF2 is scheduled to begin operating with charcoal from the second quarter of 2011.

04

Aperam

Transforming Residues into By-products

Material Efficiency

Challenge

Aperam's production lines generate an average of 740 kg of waste is generated for each tonne of crude steel produced. The management of this waste is vital for Aperam to meet its environmental commitment, and to remain competitive. This requires good waste administration, from generation, to handling and recycling and ultimately, final disposal.

The first action taken was to reduce the environmental impact of the waste generated across the whole process to enhance recycling in order to improve physical yields.

In line with Aperam's Sustainability Guidelines, a study into economical and sustainable alternative uses for waste has been initiated. Prior to 2008, only 79% of the waste generated was commercialised or reused in the production flow. The remaining 21% – or 159 kg of waste per tonne of crude steel – was stored in a waste yard.

Following a full analysis, a number of wastes were selected for further study. These included:

- Blast furnace waste such as sludge, dust from the collector, and waste generated by the Pulverised Charcoal Injection Unit.
- Saturated acids (hydrochloric and sulphuric) generated in the cold rolling mill.

These by-products were selected as they represented more than 50% of the total waste held in the yard. Applications also existed for BF wastes in Brazil.

For saturated acids, the aim was to find new waste treatment solutions that avoided the traditional process of neutralisation which generates sludge. The challenge was to identify or develop a market that was able to absorb these by-products. The waste needed to meet specific environmental legislation and be handled within a well structured internal logistics unit.

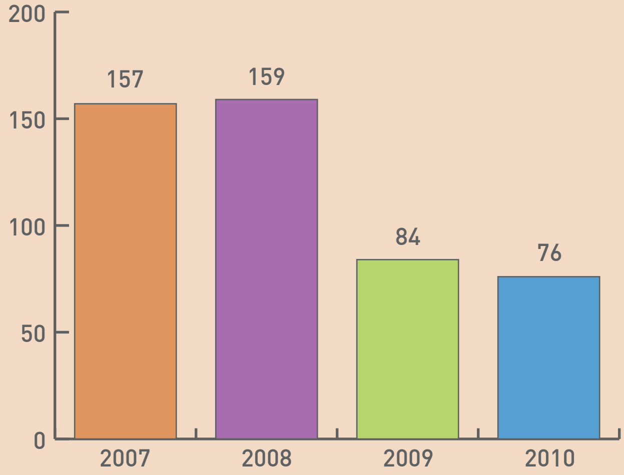
Action

A number of applications in the ceramics industry have already been developed for dust and sludge originating from blast furnaces. During the economic crisis of 2008 and 2009, Aperam began to contact potential customers for this waste.

Industrial tests were carried out to ensure that it was technically feasible for these companies to utilise the waste. Aperam also provided support to enable customers to obtain the required environmental license to receive and use these by-products. Internally, actions were taken to guarantee supply to customers.

In the case of waste from the Pulverised Charcoal Injection unit, an agreement was made with the pulverised-charcoal supplier to reduce the amount of sand used during the grinding process. For the remaining sand, an application in the cement industry was developed.

Feasibility studies into the usage of sulphuric and hydrochloric acids generated in the cold rolling mill was initiated in 2007. The use of hydrochloric acid to produce ferric chloride for water treatment and the use of saturated sulphuric acid in agricultural applications were explored. Both studies were successful.



Evolution of waste to landfill per tonne of steel produced

Outcome

Waste disposal in Aperam's internal yard has been reduced from 159 kg/tonne of crude steel produced in 2008, to 76 kg/tonne in 2010. This level has been maintained following the ramp-up in production that occurred once the global economic crisis eased.

Globally waste has been reduced by 109,000 tonnes over the past two years, enabling Aperam to extend the the life of its landfill sites and generating income from the sale of wastes.. This has led to a decrease in the amount of raw materials Aperam, and our partner companies, need to purchase.

This action is fully aligned to the values of Aperam and its goal to be a sustainable company.

05

Columbus Stainless (Pty) Ltd

Water Recycling

Material Efficiency

Challenge

South Africa is an arid country where water is a scarce resource. To ensure our long term sustainability, it is vital to ensure that the manufacturing industry in the country utilises this resource as optimally as possible.

Action

Columbus has undertaken to actively manage water at our plant and to run it as a zero-effluent site. This has meant recycling water and effluent as far as possible.

All weak effluents and storm water runoff are now treated in reverse osmosis plants. The brine from this treatment is added to the strong effluent system, while the recovered water is returned to the steelmaking system as make-up water.

In the strong effluent system, the waste matter is first neutralised and then put through an evaporator to recover water. Again, recovered water is returned to the steelmaking process as make-up water.

The brine from the evaporator is further concentrated in a crystallisation process where additional water is extracted. The salts are also recovered and sold.

Outcome

Around one million cubic metres of water is consumed in our plant each year. Thanks to the recovery system, only 12% of this comes from raw water added to the system. Over 8,000 tonnes of calcium nitrate is produced for sale.

06

JSL Limited

Resource Conservation and Pollution Control

Energy Intensity EMS Material Efficiency

Challenge

JSL has implemented a number of resource conservation and pollution control initiatives in order to:

- Ensure efficient utilisation and conservation of thermal and electrical energy at our captive power plant.
- Achieve excellence in energy conservation and management.
- Implement more energy efficiency projects at our coke oven and at the power and ferroalloy plants.
- Improve by-product recycling at our coke oven and at the power and ferroalloy plants.
- Reduce waste by adopting suitable eco-friendly processes.
- Adopt effective waste disposal methods using the 4R approach.
- Develop a fully fledged environmental monitoring and management cell.
- Spread the message of environmental awareness to all levels of personnel at JSL and to create a strong team network.
- Implement clean development mechanisms and minimise greenhouse gas emissions in every part of the plant.

Action

JSL has taken the following actions:

- Energy consumption in the electrostatic precipitator (ESP) has been reduced while the charge ratio has been increased.
- By changing the angle of the blades in the cooling tower fan, motor loads have been optimised and the number of hours the fan is in use has been reduced.
- Energy savings were achieved through optimum utilisation of the transformer.
- All fly ash generated in the Captive Thermal Power Plant is being used to reclaim a low-lying quarry just outside the plant. The work is being carried out in an environmentally friendly and sustainable way. Permission for the work was obtained from local statutory authorities such as the Pollution Control Board and District Administration.
- Fly ash is also utilised in the brick and cement industries.
- JSL has established a Centre for Environmental Excellence and state-of-the-art Environmental Laboratory to help us achieve global benchmarks.
- JSL conducts frequent environmental audits, monitoring and analysis to maintain, check and review our performance.
- The efficiency of our gas cleaning plants was increased through audits and the replacement of bags.
- A plan to create a green belt through the plant and around the periphery has been developed and implemented.
- We have implemented a comprehensive By-product (Waste) Management Plan for proper segregation, collection, utilisation and environmentally friendly disposal of all types of by-products and wastes.

Outcome

The actions we have taken have resulted in:

- A reduction in energy consumption in the cooling tower.
- Complete utilisation of all fly ash since the plant was commissioned in 2006.
- Zero effluent being discharged from the plant.
- Wide acclaim for our Centre for Environmental Excellence and its state-of-the-art technical competencies.
- Many prestigious national and state awards for environmental and safety excellence.
- An enhanced corporate image through our environmentally friendly operations has increased goodwill, confidence, and harmony with our local community.

We continue to work towards achieving zero emissions and zero wastes.

07

Nippon Metal Industry Co., Ltd.

Fully Integrated Site Design

Energy Intensity | EMS | Greenhouse Gas Emissions | Material Efficiency | New Processes & Products

Challenge

Stainless steel has excellent durability and is completely recyclable. It can truly be regarded as an Earth-friendly metal.

The process of manufacturing stainless steel makes use of energy in the form of fuels and electricity. It also creates exhaust gases and by-products. Therefore, the stainless industry must make great efforts to reduce its impact on the environment.

By saving energy, reducing by-products, and recycling resources, we can actively promote the stainless steel industry as one that contributes to the establishment of a society that is in harmony with its environment

Action

Nippon Metal Industries undertook a project to gather its hot and cold rolling and melting facilities on one site. The processing and tube shops of our partners were also included on the site to establish a fully integrated stainless steel production facility including both upstream and downstream processes.

To ensure the site operates with a high level of sustainability and efficiency, the following actions have been taken:

- An automatic guided vehicle (AGV) system has been installed to move products between the hot and cold rolling shops and the melting shop.
- The site has been converted to use liquid natural gas (LNG)
- The capacity of the shipping berth at the site has been expanded in an effort to promote direct export from the plant, thereby reducing road transport needs.
- A smelting reduction furnace has been installed to reduce waste and improve the recycling of scrap metal produced onsite.

Outcome

The fully integrated process makes it possible to shorten production lead times. Our pipe products, for example, have a led time of about one month. This is one of the lowest in the industry and is highly appreciated by customers.

Truck transport has been reduced through the use of the AGVs. Combined with the expansion of the shipping berth and the conversion to LNG have greatly reduced the CO_2 emissions from the plant.

Collection of stainless steel scraps produced onsite and the recovery of metals from dust, sludge and scales is now possible with the new smelting reduction furnace. We are able to achieve high levels of recycling efficiency. Slugs are also utilised as sub-base for road construction.

The fully integrated production site enables Nippon Metal Industry to operate a high-efficiency stainless steel production site that is an example to others.

08

Nippon Steel and Sumikin Stainless Corporation

Using a Rotary Hearth Furnace to Recover Valuable Metals

Material Efficiency

Challenge

Dust and sludge produced in the stainless steelmaking process contains valuable metals such as nickel and chromium. However, there are many challenges to be faced when recovering and recycling these products. As a result, some types of waste are disposed of in landfill after they have been treated.

Landfill disposal costs a great deal of money and means that some valuable metal resources are effectively lost. NSSC sought to find a way to recover these resources efficiently and to minimise the need for landfill disposal.

Action

Stainless steel waste contains zinc, is often powdered and oxidised, has a high-moisture content, and is difficult to recycle without pre-treating. Arc furnace dust is very fine and contains chromium oxide which has a high melting point and is difficult to reduce.

NSSC undertook research to find the appropriate mix of materials and reduction conditions. From this research, NSSC has developed a lumping and reduction technology using a Rotary Hearth Furnace to recycle stainless steel waste.

Outcome

At NSSC's Hikari Works, all stainless steel waste is recycled using the Rotary Hearth Furnace method. The wastes that are processed include arc furnace dust, sludge, mill scale, and others.

09

Outokumpu Oyj

Opencell™ Sandwich Panel Structure

New Processes & Products

Challenge

The demand for lighter constructions with better performance has emphasised the importance of efficient structures. In principle, two approaches exist to developing efficient structures: either the application of new materials or the use of novel structural design. However, a combination of both is also possible.

A proven and well-established solution is the combination of composite materials and sandwich structures. High strength-to-weight ratios with minimised weight can be obtained. Thermal insulation, good sound reduction and high specific-energy absorption are additional benefits of this construction method.

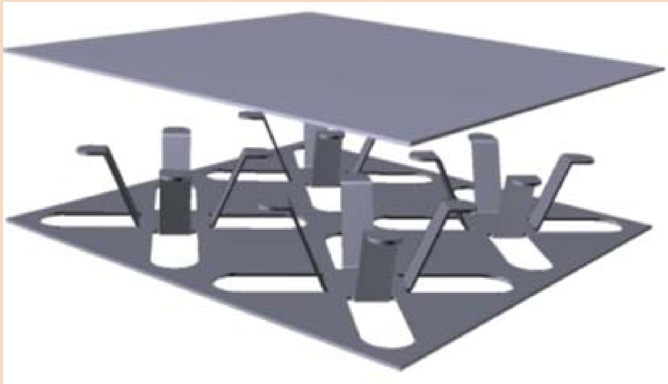
All-metal sandwich panels offer numerous outstanding properties and allow the designer to develop light and efficient structural configurations for a large variety of applications. The most established type of metal sandwich panel is created using directional stiffeners between solid surface sheets. However, the heterogeneity of strength and/or stiffness properties in both longitudinal and transverse directions is a characteristic of this type of panel.

Opencell™ Sandwich Panel

Action

The design of sandwich panels, utilising lattice truss concepts, has resulted in a completely new metal panel idea called Opencell™. Instead of a conventional, three-part panel structure (sheet/core/sheet), a combination of cut-and-formed core and single solid sheet elements are used. This creates a higher degree of design variables for tailored properties.

Several initial Opencell™ concepts were generated in a research and development project funded by Outokumpu and Tekes Technology and Innovation Agency. The aim was to evaluate and optimise the structural performance of the panel.



Detail of Opencell™ Sandwich Panel

Outcome

The patented Opencell™ technology includes a panel system where the core structure is formed from layers of steel sheets that are mechanically connected to each other. The connection members are formed from one of the layer sheets so that there is no additional core material.

This results in a higher degree of design variables for tailored properties, and increases the potential for industrialisation compared to other currently available technologies. The Opencell™ technology also offers the potential to reduce the number of elements (and thus joining phases and weight) and create free-form curved shapes. Balanced transversal- and longitudinal-stiffness properties are other key benefits.

A basic structure was designed and optimised for a combination of constant load and point loading at the centre of the sandwich panel – known as Opencell Delta™. The criterion was a maximum-allowed deflection when the panel is simply supported at both ends at a 2 metre span.

As a result of a thorough material selection process, austenitic stainless steel grade AISI 201 was used for the prototype panels because of its fine balance of properties. A simple matrix-pressing tool was used in panel production to form one row of Opencell™ units per stroke.

The prototype panels were subjected to an extensive mechanical testing programme. Based on the results of static mechanical tests on the full-size panel, it can be concluded that the Opencell Delta™ concept offers excellent weight-to-stiffness and strength-to-weight ratios. The results are comparable to, or better than similar results for conventional all-metal sandwich panels in typical load-bearing applications such as floor structures.

10

Outokumpu Oyj

Reducing Waste to Landfill

Material Efficiency

Challenge

To reduce the specific volume of waste sent to landfill and increase material efficiency by re-using waste products in the stainless steelmaking process.

Action

Establish a sustainable recovery and re-use route for stainless steel waste such as:

- Recovered slag to be re-used in the production of asphalt.
- Waste refractory material to be used as a substitute for limestone in the stainless steelmaking process.

The recovery rate of waste material has to be sustained at a level where it can meet demand.

Outcome

In 2007, Outokumpu's Sheffield melting shop (SMACC) sent 103.8 kg of waste to landfill for every tonne of steel produced. Using the two actions detailed above, this had been reduced by 44% to 57.8 kg/tonne by the end of 2010. The reductions have been sustained over a three-year period and represent the start of SMACC's journey towards becoming a zero-waste-to-landfill steelmaking facility.

The schemes, championed by the SMACC operational teams and also in partnership with the Harsco Group, have led to the dramatic reduction in waste to landfill. Since 2007, over 80% of all slag produced has been recovered and re-used as road stone in the production of asphalt. During 2010, half of all refractory waste generated on site was re-used as a lime substitute.

The use of steelmaking slag in asphalt production has many great social and environmental benefits. Slag increases the durability of road surfaces, reducing the need for road repairs and associated traffic delays. The surface of the slag-containing asphalt also exhibits good grip values, skid resistance, rut and deformation resistance, and reduces the risk of aquaplaning.

Using slag as a substitute for a natural resource also reduces the need to actively damage land by mining for virgin raw materials. This helps to alleviate the pressure that mining can exert on communities and ecosystems in the vicinity of mines and preserves the natural beauty of the area.

The recovery and re-use of refractory material as a lime substitute means that Outokumpu's dependence on virgin lime also decreases. With waste refractory material being reused in the steelmaking process as a slag conditioner, it effectively ends up in the slag. This means it is effectively used three times: once as refractory brick, again as a substitute for lime in the formation of slag; and finally as a substitute for road stone in asphalt production.

11

Outokumpu Oyj

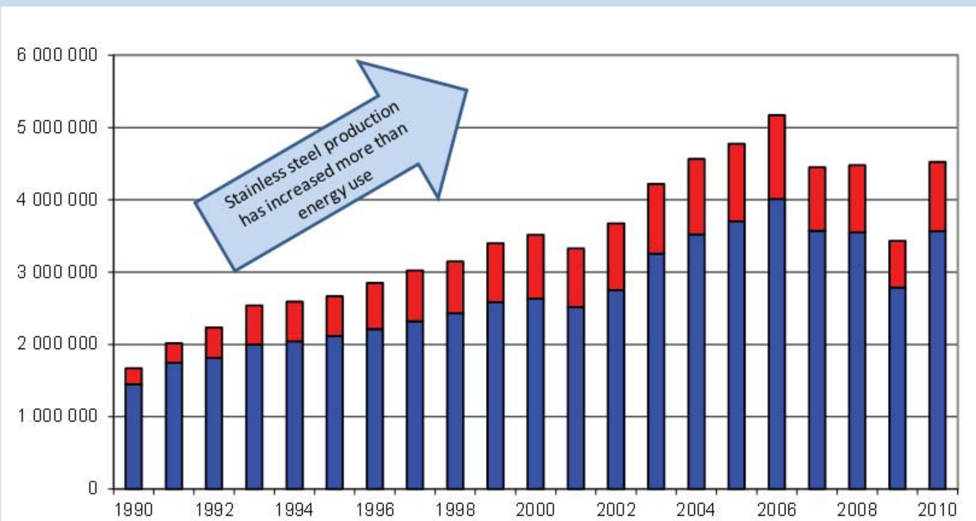
Creating Long-term Energy Efficiency and CO_2 Emission Improvements

Energy Intensity Greenhouse Gas Emissions

Challenge

The amount of energy used in the stainless steel industry and its resultant carbon footprint are quite high compared to some other industries. Emissions of CO_2 are synonymous with the use of energy. In stainless steel making they come from the fuels used to power electric arc furnaces (EAF), hot rolling (HR) and cold rolling (CR).

During the 1990s, Outokumpu's Tornio Works started a systematic long-term action to improve energy efficiency. The main aim was to save energy and energy related costs. However, a secondary goal was to systematically lower emission levels, and therefore the carbon footprint of our stainless products. The energy efficiency action at Tornio Works has been monitored, assessed and reviewed annually.



Energy savings (red bar) in megawatt hours at Outokumpu's Tornio Works

Action

The main actions have been:

1. Investments in our own unique technologies including:
    - Use of molten ferrochrome (FeCr) to melt recycled steel (known as a chrome converter).
    - Creation of the first totally integrated and industrial-scale cold rolling line.
    - Use of carbon monoxide gas (a by-product of the FeCr plant) to replace other fuels at the steelworks.
2. Energy efficiency investments in certain areas of the mill including:
    - Waste heat recovery from furnaces.
    - Regenerative burners in the hot rolling mill furnace.
    - Installation of a combined heat and power plant (CHP or cogeneration plant) which utilises peat and bio-energy and replaced existing oil-based heat boilers.

Outokumpu also purchases electricity that is mainly generated using non-fossil resources. This reduces our indirect CO_2 emissions.

The energy efficiency action programme is part of a local environmental management system (EMS based on ISO 14001). The latest action programme will run from 2011 to 2016.

Outcome

The long-term energy efficiency action plan has decreased annual energy use in several production phases. Based on an average production year, the main energy savings have been:

- 150 GWh/year at the steel melt shop using the chromium converter.
- 80 GWh/year at the hot rolling mill by hot charging slabs.
- 500 GWh/year using carbon monoxide to replace other fuels.
- 600 GWh/year from the recovery of energy from waste water, waste heat and gases.

Without these improvement actions, the energy consumption at our Tornio Works would be almost 30% higher than it is today. The actions have also decreased specific carbon dioxide emissions from Tornio steel mills by 30% in two decades (1990-2010). Together with the changes made to the energy and electricity supply mix, the mean carbon footprint of Outokumpu's main products has decreased by almost 40% since the 1990s.

12

Outokumpu Oyj

Assessing the Long-term Effects of Exposure to Metals in Stainless Production

Safety

Challenge

Employees working in the stainless steel industry are exposed to potentially carcinogenic and toxic materials every day. Outokumpu wanted to understand the actual exposure levels and the chemical composition of the inhaled particles and to answer questions such as:

- Is it possible to stay healthy throughout an entire career in the stainless steel industry without contracting occupational diseases?
- How should we run proper periodic health examinations and effective health promotion campaigns?
- Are modern laboratory methods, such as the assessment of the micronuclei of nasal cells, useful tools to define the early biomarkers of potential cancer-forming cells in the respiratory tract?

An essential part of the challenge was to demonstrate that healthy and safe working conditions in the production phase are fundamental for the sustainability of stainless steel as material of the future.

Action

A systematic scientific research programme was developed in 1986, and has been carried out at Outokumpu's Tornio Works (Finland) in close cooperation with universities and expert institutes. In total, 316 workers participated in the follow-up studies. Their average exposure time was 23 years.

The studies have covered exposure characteristics, long-term respiratory health effects, nasal cell mutagenetic effects and magnetopneumographic examinations to determine the rate of dust retention in the lungs.

The results of the studies have been published as six individual articles in international scientific medical journals between 1993 and 2002. A new phase of the research programme is on-going.

Outcome

The exposure study showed that there is certainly exposure to chromium and nickel throughout the production chain, and to harmful hexavalent chromium at certain stages. However, the observed health effects were minimal. This finding can be explained partly by low exposure levels and partly by the low bio-availability of potentially harmful chromium species. The low bio-availability can be explained by the surface properties and chemical composition of the metal particles in the workplace air.

The clinical studies indicated that an average exposure time of 23 years in ferrochromium and stainless steel production, including exposure to dusts containing low concentrations of chromium and nickel compounds, do not lead to any respiratory changes detectable by lung-function tests or radiography nor to any increase in symptoms of respiratory diseases. Nor does this exposure lead to nasal changes detectable by clinical or cytological examination. No genotoxic effects attributable to occupational metal exposure could be observed.

The results demonstrated that the modern stainless steel production chain achieves low metal exposure levels with no adverse health effects. Results of the studies have been used in European Union chemical safety procedures (such as REACH) and to scientifically show the health effects of stainless steel and industry.

Recommendations for health examinations have also been made based on these studies.

The publication of the results in open literature has made them available to the global stainless steel community and its stakeholders.

The scientific studies form the basis of the Finnish Institute of Occupational Health's (FIOH) Review of the Toxicity of Stainless Steel, conducted in 2010. For more information on this study, please visit:

http://www.ttl.fi/en/publications/Electronic_publications/Documents/Stainless_steel.pdf

13

POSCO

Recycling AOD-slag

Material Efficiency New Processes & Products

Challenge

In the stainless steel production process, argon oxygen decarburisation (AOD) slag is produced as a by-product. At POSCO, about 100,000 tonnes of AOD-slag is made during a typical year.

AOD-slag is recycled with electric arc furnace (EAF) slag using the wet-type process. However, 60% of steelmaking slag is sent to landfill.

The wet-type recycling process needs a large area to enable the slag to be cooled, and a complex facility to crush, screen and dry the slag. Dust and waste water produced during the recycling process can cause environmental problems. Therefore, the development of an environmentally friendly, but simple recycling process is needed.

Action

Because of the volume expansion caused by the phase transformation, AOD-slag becomes powder during the cooling process. Using this powdering phenomenon, the development of a dry-type recycling process is possible.

POSCO has developed such a process and built the AOD-slag recycling facility. The new facility has the capacity to process 170,000 tonnes of AOD-slag each year.

The dry-type process only needs a simple facility as the slag does not need to be dried and crushed. The operation can also be closed, avoiding dust and waste water generation.

Recycling type	**Dry**	**Wet**
Investment (US$ millions):	$13.3	$17.7
Site area (m^2):	3,230	5,100
Water consumed (ton/day):	100	300
Waste water (ton/day):	0	2,500

Outcome

Since 2003, all products produced using the dry-type process have been utilised as a filling material for cement.

In earlier years it also had uses as a base material for fertiliser. However, due to potential environmental issues with fluoride, all of the material produced is now used as filling for cement.

By recycling AOD-slag, POSCO has reduced its landfill needs by 10%.

14

POSCO

Creating FeNi Pellets from Industrial Waste

Material Efficiency New Processes & Products

Challenge

During stainless steel production, nickel-containing by-products such as dust and sludge are produced. The dust from the steelmaking process is recycled in the electric arc furnace (EAF). However, most sludge from the annealing and pickling process is sent to landfill.

Electricity and petrochemical manufacturing processes also produce nickel-containing wastes such as catalyst residue and sludge. These wastes are also sent to landfill.

The total amount of nickel contained in the by-products and wastes produced by POSCO is approximately 1,000 tonnes annually. The by-products and wastes can be used as a raw material for nickel ferroalloys. However, as there was no economical extraction technology, most were also sent to landfill.

Action

POSCO has developed an extraction technology to remove nickel from industrial waste. Construction of a recycling plant which can process 60,000 tonnes of waste a year has been completed. This plant will produce 1,000 tonnes of nickel in the form of ferro-nickel cold-bonded pellets (CBP) annually.

The new recycling process is based on wet-refining technology and has higher energy and cost efficiencies than the smelting process. The process can decrease CO_2 emission by using less energy and producing nickel at 60 to 80% of the cost of the smelting process.

The process can also extract nickel from wastes with low levels of the metal. This suggests that the process can be used to refine low grade ore.

Because the technology uses the wet-refining process, dust generation is reduced. The process also removes toxic material in the waste by reducing hexavalent chromium (Cr+6) to the oxidation state (Cr+3).

Outcome

By the end of 2010, 16,500 tonnes of ferro-nickel CBP had been produced. Ferro-nickel CBP is used in POSCO's stainless steelmaking process and contributes significant cost savings. It reduces waste sent to landfill by 34,000 tonnes/year. By utilising the technology, POSCO estimates that the global stainless industry could save at least US$250 million in environmental costs each year.

The technology was recognised for its creativity and technical excellence with the presentation of the 2010 Korea National Green Technology Award.

15

Sumitomo Metal Industries, Ltd.

New Stainless Steel Boiler Tubes for USC Power Generation

Greenhouse Gas Emissions

Challenge

Stainless steel boiler tubes are used for thermal power generation boilers which create electricity by burning fossil-fuels, such as coal or oil, and producing steam. The temperature of a conventional supercritical-pressure steam has been limited to around 566ºC. If this is increased to 600ºC at ultra-supercritical pressure (USC), the heat-efficiency of the boiler is increased and CO_2 emissions are greatly reduced.

However, conventional steel boiler tubes do not have enough strength and corrosion resistance at high temperatures when the steam is at USC conditions. For this reason, conventional stainless steel boiler tubes have not been used at temperatures above 566ºC.

Action

Sumitomo Metals has developed three stainless steel boiler tubes that meet the requirements for a USC boiler:

1. TP347HFG. Developed by optimising alloying elements within the standardised chemical composition range of conventional stainless steel type 347H (18Cr-12Ni) and applying a unique thermo-mechanical manufacturing process. TP347HFG has 1.3 times the strength and three times the steam oxidation resistance of conventional type 347H boiler tubes.
2. SUPER304H. Developed by adding copper and nitrogen while dramatically reducing the content of high-priced nickel and niobium. The unique thermo-mechanical manufacturing process is also applied to achieve high strength and steam oxidation resistance with a fine-grained microstructure. This steel has twice the strength and three times the steam oxidation resistance of conventional type 347H steel boiler tubes.
3. HR3C. A high-chromium steel which has superior hot-corrosion resistance to the conventional type 347H stainless steel in a coal-fired boiler with a high-sulphur content. Finely dispersed precipitates created during service operation are improved at high temperatures. A practical service-exposure test of HR3C-steel boiler tubes has been successfully conducted for over 13 years, demonstrating the high quality and superior performance of the tubes.

These products are utilised for integral components of the USC boilers such as the superheater and reheater tubes which generate the high temperature and USC pressure steam.

Outcome

Use of the new stainless steel boiler tubes has made it possible to build high temperature, high pressure 600ºC USC boilers. A 4% improvement in heat efficiency (compared to conventional technologies) has enabled coal consumption to be reduced by 3.98 million tonnes (mt) per year in Japan.

The new stainless steel boiler tubes have become a global standard, capturing almost 100% of the Japanese market and more than 80% of the global market for USC boilers. This USC boiler is experiencing a boom worldwide.

There are 80 boilers currently in operation globally, a number that will increase to 191 if all planned systems come to fruition. The technology will reduce coal consumption at these 191 power plants by 27.7 mt/year. It is estimated that improvements in heat efficiency will reduce CO2 emissions by 4.6 mt/year in Japan and 67 mt/year worldwide.

There is no doubt that the contribution of these new stainless steel boiler tubes to reducing the environmental impact of power generation will continue to grow.

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ThyssenKrupp Nirosta GmbH

Improving Corporate Safety Culture

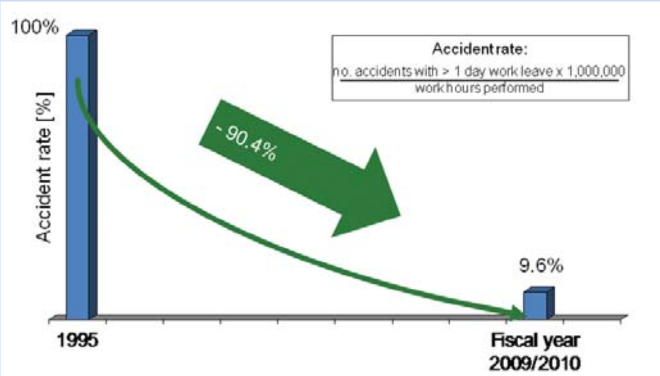
Employee Training Safety

Challenge

Every accident is one too many! Every accident is preventable!

Our corporate goal was to reduce the number of work-behaviour based accidents in order to:

- Reduce personal harm and suffering.
- Increase awareness that the company cares for the welfare of its employees.
- Enhance motivation and work satisfaction.
- Reduce inactive periods (medical leave, machine downtime).
- Improve operator ergonomics.
- Improve our corporate image among the general public.
- Improve corporate performance.



Action

Seminars and workshops for executives, supervisors and employees were held to:

- Establish a uniform knowledge of safety values and standards at all levels of the organisation.
- Analyse accidents and close-call experiences from the past in order to prevent their recurrence.
- Identify and analyse risky behaviour, with the aim of improving personal behaviour.
- Enhance awareness and concern, using both the rational and emotional approach.
- Offer safety training and definition of key measures in small groups.

Outcome

The action has resulted in a significant reduction in behaviour-based accidents. The rate of accidents has decreased by more than 90% between 1995 and the 2009/2010 fiscal year.

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YUSCO

Improving Energy Efficiency and Reducing Greenhouse Gases

Greenhouse Gas Emissions

Challenge

Greenhouse gas reduction is currently the most important topic in the stainless industry, particularly given the energy-intensive nature of the process. YUSCO continues to improve its energy efficiency and has actively participated in a government programme to voluntarily reduce its CO_2 emissions since 2005.

Action

By strengthening energy management and improving energy efficiency, YUSCO has been recognised as a leading energy-saving company for the past four years by the government Ministry of Economic Affairs.

The following actions have been taken to save energy and reduce greenhouse gas emissions:

- In the hot strip mill, the hot-charging rate has been increased to 450°C (up 60%).
- By connecting the pipes between various compressor systems, power consumption has fallen by 11%.
- Aluminium electrode arms have been installed in the electric arc furnaces (EAFs) to increase the efficiency of electrical transmission.
- Fans and blowers in the de-dusting system have been altered to use a variable voltage variable frequency (VVVF) system.

Outcome

For the past five years, YUSCO has reduced its CO_2 emissions by 10,000 tonnes annually on average. The company continues to participate in the government's 'Voluntary CO_2 Emissions Reduction Agreement', committing to reduce CO_2 emissions by 50,000 tonnes over the next five years.

Future actions to be taken include:

- Further increasing the hot-charging rate and temperature.
- Minimising heat loss through effective management of the steam system to reduce the amount of heavy oil consumed.
- Modification of the ladle pre-heater for oxygen-enriched steel in the steelmaking plant, and installing optimal-control software to reduce power consumption in the EAF plant.

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