NICKEL

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

Stainless Steel & China's Energy Sector

India's Sustainable Transportation

Nickel-Containing Stainless Steel Supporting Farmers

August 2012 Vol. 27, Nº. 1

The History of Stainless Steel – Part 1

Developments before the Discovery of Stainless Steels

Archeologists say iron was first used in tools as early as 2,500 B.C. in what they call the Bronze Age. Once refining techniques were improved, iron became relatively inexpensive; however, iron's main disadvantage over bronze was that it rusted when wet. This meant, taking a modern example, that cutlery made of iron or steel had to be washed and dried immediately after use, otherwise it would rust. It was clear to all that there was a need for a rust-less iron, that is, an inexpensive material that did not rust.

The story begins with the discovery of nickel by Axel Fredrik Cronstedt in Sweden in 1751. Although chromium is the essential element for making a steel rust-less, nickel was used prior to the development of stainless steel to make iron less prone to corrosion and later became a key ingredient in the dominant family of stainless steel.

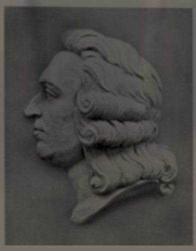
The second step came with the discovery of chromium metal in 1797 by Louis Nicolas Vauquelin, a French chemist. Chromium metal was brittle but only weakly reactive with acids.

In 1821 Pierre Berthier, also French, economically produced ferro-chromium metal by heating mixed oxides of those two metals with charcoal. He found that ferro-chromium could easily be added to iron to make chromium steels. Berthier reported on the increased corrosion resistance of the high chromium steels he had made, but unfortunately the high carbon content in the ferro-chromium prevented the alloys from exhibiting a rust-less property. They were also quite brittle.

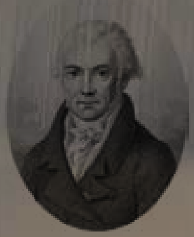
In the mid-19th century, there was considerable development of steels with a low percentage of chromium to improve their hardness and corrosion resistance. Commercial development of the higher-chromium steels would have to wait for the work of German chemist Hans Goldschmidt. Goldschmidt is best known for the thermite process, which uses aluminum powder instead of carbon to reduce the metal oxides to pure metal. This could be applied to chromium too, and in 1895 low-carbon ferro-chromium was produced. Its availability allowed researchers not only to determine the detrimental effect of carbon on the corrosion resistance of the higher chromium steels, but to make lower carbon alloys.

The stage was set for the development of stainless steels.

Iron age tools
1000–700 BC



Axel Fredrik Cronstedt
1751



Nikolas Vauquelin
1797

Pierre Berthier
1821

Hans Goldschmidt
1895

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The Magazine Devoted to Nickel and its Applications

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SUSTAINABLE DEVELOPMENT WITHOUT A DEADLINE

It has been 20 years since the first Rio de Janeiro Sustainability Summit, which in June 2012 returned to the city of its origin. As is normal for such meetings it received mixed reviews of its decisions and commitments on its major themes of employment, energy, cities, food, water, oceans and disasters. For more on its objectives, see www.uncsd2012.org/rio20/objectiveandthemes.html

The reality is that the struggle for sufficient food, non-polluting energy, safe and reliable transportation and other measures of a quality of life that is both improving and sustainable doesn't have a beginning or an end. It does, however, have its moments when sustainable choices are made that deliver on one or more of the themes of Rio+20 and in every issue of *Nickel* there are stories of such choices.

In this issue, the article "Waste Not" shows how nickel-containing stainless steels are bringing appropriate technology closer to farmers, co-operatives, and small-holders (single-family subsistence farms) in developing countries. Alarmingly, an average of 150 kilos of food per person per year is lost or spoiled in the early stages of production in such regions. Anything that reduces that loss will naturally reduce hunger, improve returns for farmers, and ease pressure on the land…and stainless steels are helping.

In India, nickel-containing stainless steels have long been used in railcars, and the country's ongoing economic expansion is resulting in the manufacture of many more for use on commuter lines in Mumbai, New Delhi and Bangalore. The article "Stainless Express" shows how the quality of life in India's large and growing urban centres can be achieved economically and with reduced environmental impact.

On page 10 you will read how nickel-containing stainless steels are helping the expansion and diversification of China's energy sources. The focus isn't just on coal anymore: solar power and bio-fuels join hydro, nuclear and other sources, and in all of them you will find nickel making it work as China continues its extraordinary journey.

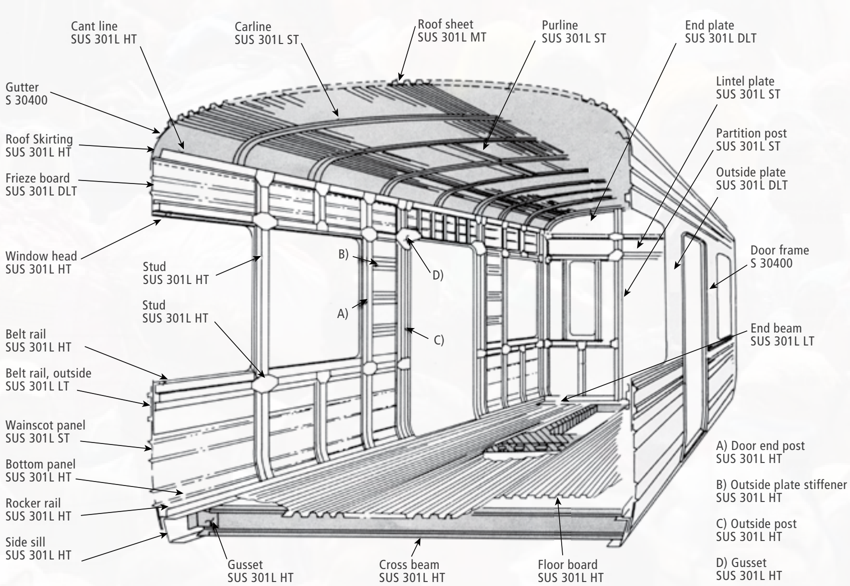
Rio+20 has come and gone but nickel will continue to play a crucial role in supporting sustainable development every day.

There is more, of course, and continuing our attention to the 100 anniversary of stainless steel, see the opposite page for the first of a series of articles that will provide much more information on the evolution of that essential group of alloys.

And lastly, why not subscribe to *Nickel*? Electronic copy or printed copy, it will be our pleasure to add you to our distribution list. Simply go to: **http://www.nickelinstitute.org/NickelMagazine/Subscription** and subscribe.

Stephanie Dunn
Editor, Nickel Magazine

STAINLESS EXPRESS



Code: LT: low tensile; DLT deadlite panel; ST special tensile; MT medium tensile; HT high tensile

Photo Captions

Upper: Bombardier Movia metro cars

Image of interior: A lightweight stainless steel car can weigh about four tonnes less than one made of steel.

Illustration: Main stainless steel carbody materials.

Bringing Sustainable Transport to Urban Life

Rail transportation is a long-established, reliable, energy-efficient and economical way to move people, whether for inter-city travel or shorter commuter journeys. Most highly populated developing countries such as India and China understand the connection between this part of their infrastructure and their successful economic development. For example, India is a country with ambitious plans to expand its people-moving systems considerably over the next decade.

At 159 years, Indian Railways is Asia's oldest rail network. In July 2009 the Minister of Railways announced that India would build more railcars and upgrade infrastructure to compete with highways in the world's second-fastest growing major economy. The Minister stated that Indian Railways, which employs around 1.4 million people, plans to set up a factory to produce about 500 railcars a year. These new railcars would join those already in service to help carry India's 15 million daily commuters.

Why nickel-containing stainless steels

New trains have recently been, or shortly will be, added to commuter systems in Mumbai, New Delhi and Bangalore. To make the railcars strong and long-lasting and reduce life-cycle costs, nickel-containing Type 301L (UNS S30103) stainless steel was selected for the car bodies. The "L" denotes a low carbon content which helps prevent intergranular corrosion attack at welded joints. Seat frames and certain interior components will be made of Type 304 (S30400) stainless steel, which has better corrosion resistance.

Some railcar builders use Type 301LN (S30153) stainless steel which contains a small amount of nitrogen to boost strength and corrosion resistance.

In contrast to plain carbon steel and low-alloy weathering steels, Types 301L, 301LN and 304 stainless steels have superior atmospheric corrosion resistance and their surfaces remain free of corrosion products and stains. These alloys perform better than aluminum in more corrosive locations, such as in high-humidity environments, and stand up well to constant daily wear. As they are easy to cut, form and weld, fabricators value their ease of handling.

The clean, shiny surfaces of stainless steels have a strong aesthetic appeal and for most railcars, the surfaces are left unpainted. Thus initial painting and future re-painting costs are eliminated and the release of any volatile organic compounds into the environment is avoided. Dirt, grime and graffiti can be easily removed from the paint-free surfaces during regular car maintenance.

Nickel-containing stainless steels possess a useful combination of strength, ductility and toughness, which is to say they are highly resistant to impact. When they are cold-worked or cold-deformed (bent), their strength and hardness increase. This combination of properties makes them ideal materials for use in the end-sections of railcars – often called "crumple-zones." In the event of a crash or a derailment, these zones are designed to collapse in a controlled way to absorb much of the impact energy and hence protect passengers in the main section of the railcar.

> India is a country with ambitious plans to expand its people moving systems considerably over the next decade.

Environmental advantages

An ideal sustainable system should be able to operate effectively for an indefinite period without damaging the environment or depleting natural resources. Large amounts of energy and resources are required to produce basic metal products, such as bar and plate. The fabricating and finishing of metals require further energy and materials (e.g., paints), and these activities can have a harmful impact on the surrounding environment.

The use of stainless steels reduces many of these impacts. Stainless steel railcars have a long service life and low maintenance requirements, thus eliminating the need for "new" metals for repair work or replacement.

At the end of their life, stainless steel car bodies have significant scrap value. It has been estimated that about 90% of all stainless steel is melted down and made into new product forms. Most of the stainless steel railcars that have so far been taken out of service have been completely restored and returned to service.

Thanks to a favourable strength-to-weight ratio, a stainless steel railcar can often be about 4 tons lighter than an equivalent carbon or low-alloy steel car. The reduction in car weight means less energy is required to propel the train per traveler-kilometer and this in turn reduces the emission of harmful greenhouse gasses. In addition, the lower energy and maintenance requirements generate economic efficiencies and the savings can be put toward other vitally important areas of public expenditure.

Today stainless steels are used in a wide range of rail applications such as inter-city, commuter, metro, subway and light-rail systems. Making passenger railcars from nickel-containing stainless steels ensures longevity, reduced energy consumption, low maintenance costs, ease of cleaning, crash resistance, and a durable, aesthetic appearance.

The use of stainless steel for railcars is a shining example of "doing it right the first time." Ni

light-weight innovation

ISTOCK PHOTO © ALEXANDER POTAPOV

The creation of a shock-absorbing nickel lattice of extremely low density is expected to benefit various industrial sectors, including vehicles, aircraft and batteries.

It is in fact the world's lightest solid material, with a density of only 0.9 milligram per cubic centimeter. That's not including the air in or between its tubes. All in all, the lattice is about 100 times lighter than Styrofoam™. It can easily sit atop a dandelion seed head without harming it.

The material was developed by a team of researchers from the California Institute of Technology, HRL Laboratories, LLC, and the University of California, Irvine.

The so-called "micro-lattice" was designed chiefly to absorb sound, vibration and shock, though HRL's research team is quick to point out other possible uses. These include applications involving lithium-ion batteries, air-cooling devices for computers, and the manufacture of cars, airplanes and spacecraft which require light-weight metals.

Amazingly, the structure consists entirely of hollow tubes of nickel.

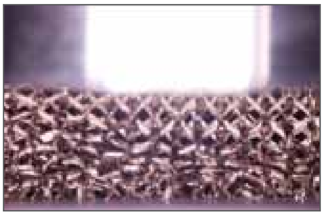
The assembly process involves fabricating a lattice of interconnected hollow tubes made of nickel-phosphorus with a wall thickness of 100 nanometers, or 1,000 times thinner than a human hair, explains Tobias Schaedler, a research staff scientist at HRL Labs. The design suggests a small-scale version of the Eiffel Tower, i.e., strong but consisting mostly of air. The lattice's hierarchical architecture allows it to recover almost completely from loads that compress it by as much as 50%, translating into an exceptional ability to absorb energy. In this respect, the material is similar to elastomers which are valued for their ability to withstand shock.

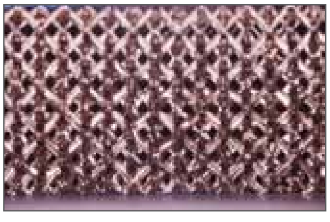
> "Nickel has very high stiffness and, with appropriate conditions, can exhibit high strength"

To make the micro-lattice, researchers use resin to create multiple, interconnected polymer fibres. The resin is then washed away and the fibres are coated with a layer of nickel. The fibres are then in turn dissolved, with only the lattice remaining.

Nickel or nickel-phosphorus can be used in the construction process because they can be deposited conformally onto the polymer template using electro- or electroless deposition.

"As well, nickel has very high stiffness and, with appropriate conditions, can exhibit high strength," says Bill Carter, Bio and Nanomaterials Technologies Manager for HRL Labs. "Both properties are important because of the post-process that enables the polymer to be removed without significantly damaging the deposited nickel or nickel-phosphorus." The United States Defense Advanced Research Projects Agency (DARPA) commissioned the micro-lattice research project. The research team now has two to three years to develop and improve the material. The Office of Naval Research has already asked them to devise variations that could withstand vibrations from blasts. Ni





▷ *The density of the nickel "micro-lattice" is so extremely low that it can easily perch on top of a dandelion seed head (Copyright 2012 HRL Laboratories – All rights reserved. Photo: Dan Little Photography)*

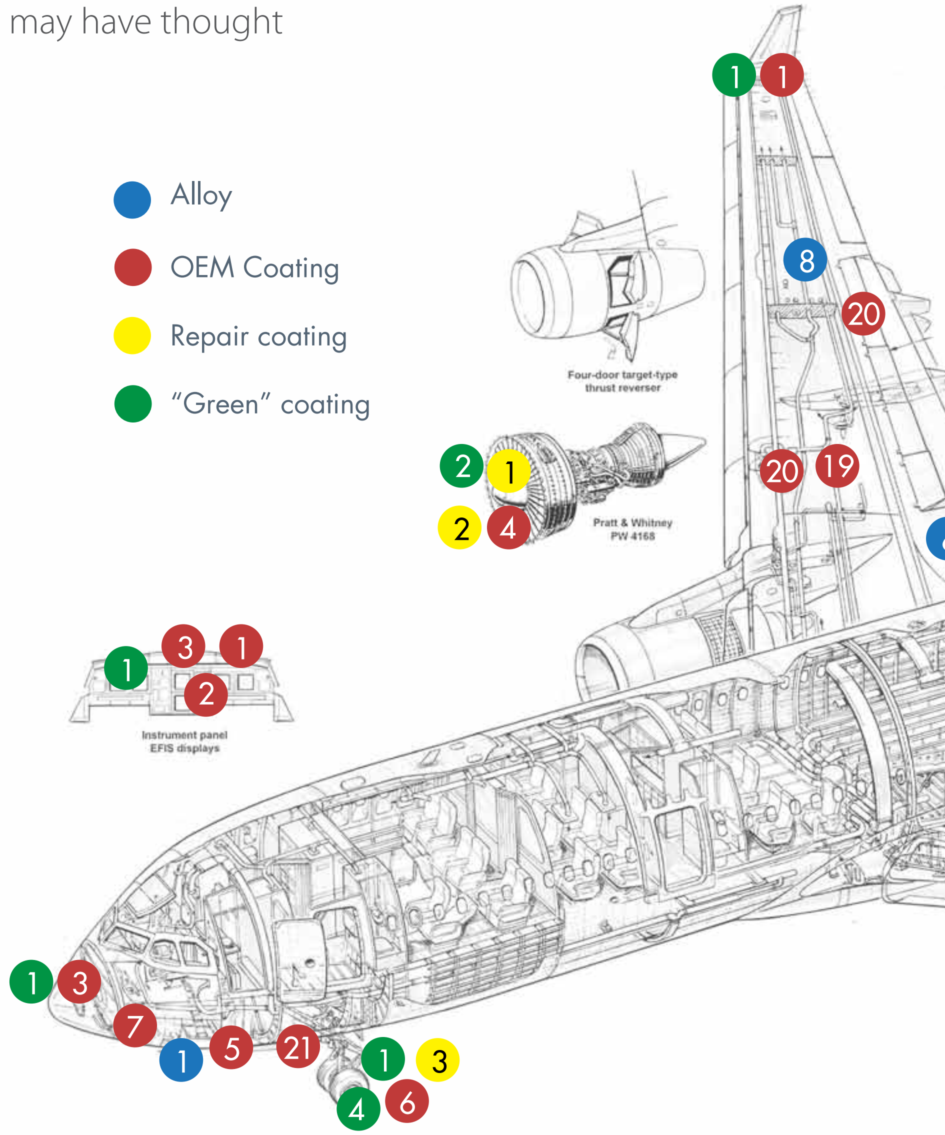
◁ *The nickel lattice is compressed, then rebounds, as is shown here. Following a compression of 50%, it rebounds to 98% of its original height. (Copyright 2012 HRL Laboratories – All rights reserved.)*

PHOTO BY DAN LITTLE © HRL LABORATORIES, LLC.

Taking off with Nickel

More nickel in an airplane than you may have thought

> This schematic is, in spite of the apparent complexity, greatly simplified: if every nickel-containing part were labeled in the same way, the image of the aircraft would be totally obscured.



The advantages of nickel in aircraft engine turbines are well-known and include high-temperature strength, toughness, durability and castability. Many might have thought that this application (perhaps along with the use of stainless steel in the washrooms and galleys) were the end of nickel's contribution.

Not at all.

The nickel superalloys in the engine account for a single dot (blue 2) on the schematic. So what do all the other dots represent and why are they there?

While the nickel in the engines helps generate the power necessary to get the aircraft off the ground, nickel in many other forms and applications – and in many thousands of individual parts in each aircraft – keeps it in the air through all its years of service.

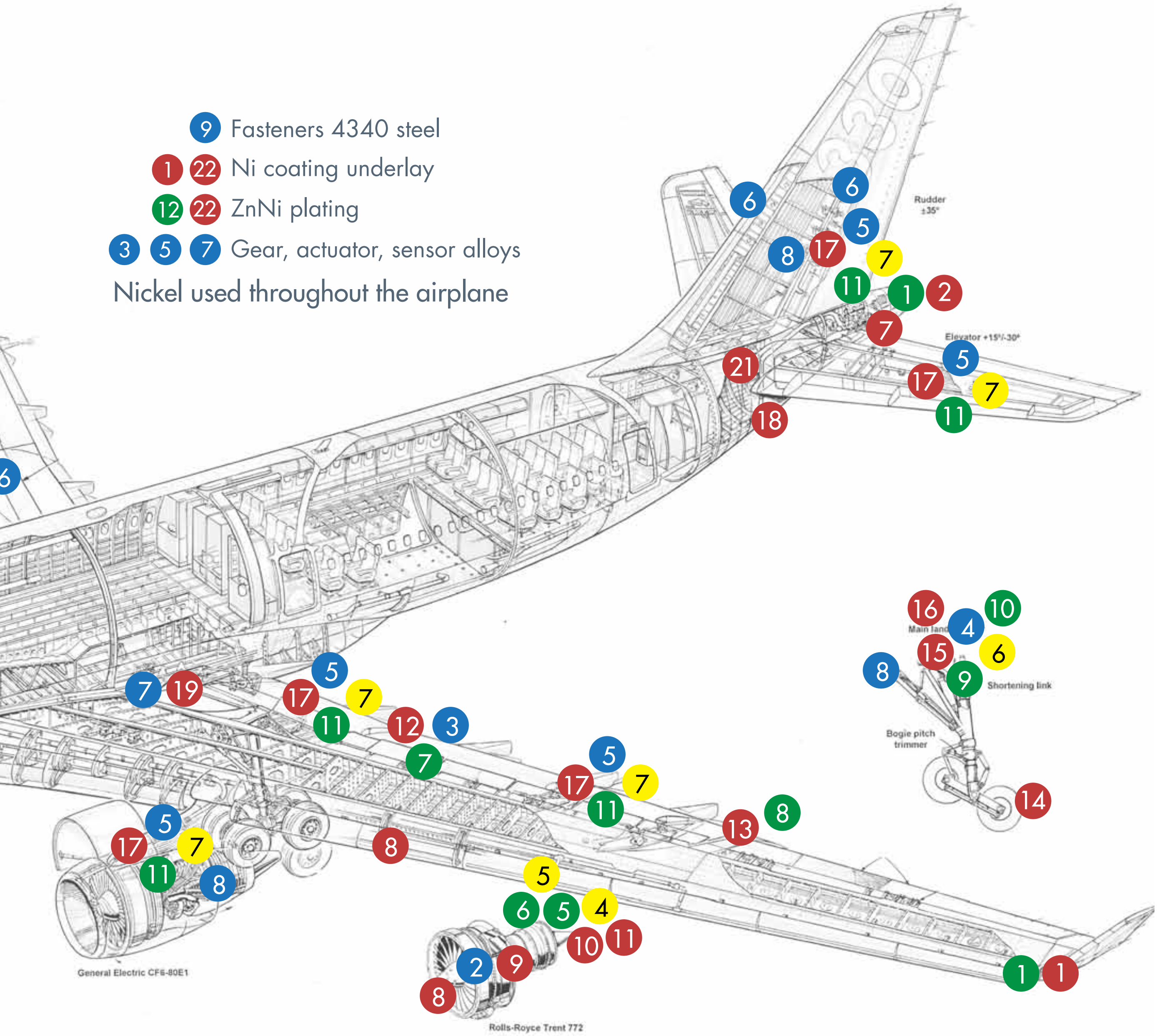
Blue Red Green Yellow

Apart from the engines, nickel-containing alloys are applied wherever strength and wear resistance are essential, such as in landing gear, valves, pumps, rods and hydraulics. These are indicated by blue dots.

Plated or coated parts purchased from suppliers (OEM or "Original Equipment Manufacturer" parts) are indicated by red dots. In every large aircraft there are thousands of electrical connectors and material fasteners where nickel provides the substrate for surface coatings of gold, cadmium or zinc, in addition to its own corrosion resistance, electrical conductivity, and strength. Sometimes the roles are reversed, an example being the nickel plating on the aluminum frame that holds the flight recorder, or "black box" (red dot 18).

Green dots are plated or coated parts where a coating involving nickel is replacing one that is deemed to be environmentally undesirable, such as hexavalent chromium or cadmium. Here nickel is applied mainly to prevent wear or corrosion.

The service life of an aircraft is demanding. Traditional repair work is to be expected, such as repair coatings of different types,



indicated by yellow dots. Routine servicing is performed at different points determined by the number of cycles (one take-off and landing = one cycle), years of service, and service environment (temperature, humidity, exposures to salt and cleaning fluids, etc.). Here, again, the uses of nickel relate mostly to corrosion and wear resistance.

Flying with nickel, flying safely

Aircraft manufacturers go to great lengths to ensure that their products are safe, that strength is beyond merely adequate, and that corrosion is anticipated and managed as efficiently as possible.

Little surprise therefore that nickel is ubiquitous in these machines which figure so prominently in our daily lives.

To view this schematic in its entirety, please visit:
http://www.nickelinstitute.org/NickelUseInSociety/MaterialsSelectionAndUse/~/media/Files/NickelUseInSociety/Aero--Nickel%20Coatings.ashx

Aerospace Nickel Coatings & Alloys Schematic originally produced by the National Association for Surface Finishing (NASF) and the Nickel Institute.

AIRPLANE (AIRBUS A330) CUTAWAY COURTESY OF FLIGHT GLOBAL.

STAINLESS STEEL DRIVES CHINA'S ENERGY SECTOR

The world is familiar with the amazing growth of the Chinese economy over the past two decades. One need only look at stainless production. In 2000, China was the 15th-largest producer of stainless steel as well as the largest importer of stainless steel worldwide. Today China is the number-one producer of stainless steels by a wide margin. The increase in industrial activity has been followed by an equally impressive increase in the Chinese standard of living. Residents now want modern home appliances including stoves, computers, TVs and air conditioners. And they desire mobility, which often means their own vehicles for travel.

All this requires energy and the demand for all types of energy has increased accordingly. Figures vary but all show that China has caught up with and possibly even surpassed the U.S. as the world's largest consumer of energy. The U.S., however, is still the largest per capita user of energy, consuming about five times more energy per person than is consumed in China.

In many ways, China's growth is similar to other emerging economies although none of them are experiencing anything like the explosive growth of China. Energy is required for materials such as concrete and steel needed for the development of infrastructure (buildings, water lines and sewers, highways, public transit systems, and so on). Rural populations typically use lower amounts of energy but they use it less efficiently. So while the efficiency of energy usage increases as the population shifts to cities, significantly more energy per capita is required.

China has a large supply of easily accessible coal; in 2008 reserves were estimated at 114.5 billion tonnes. It is no surprise, then, that even today more than three-quarters of China's electricity comes from coal. Even though flue-gas desulphurization and electrostatic precipitators can be used to clean up the sulphur and particulate emissions from these plants, coal as a fuel emits disproportionately high amounts of carbon dioxide and other greenhouse gases (GHG). In 2007 China surpassed the U.S. as the world's largest emitter of GHG, and as energy consumption increases, so do GHG emissions.

Owing to its large size and the large number of well-trained professionals among its citizenry, China is in a unique position to improve on the existing fossil fuel processes and also to develop alternative and renewable energy sources. Indeed, in 2011, Chinese investment in renewable energy totalled US$52 billion, the largest of any country and accounting for about 20% of the total world investment in that sector. China has a target of 15% non-fossil energy by 2020 whereas in 2011 it was about 9.4%. That might seem like a small increase, but it should be remembered the China will also be adding 1,000 GW (GigaWatts) of new electrical power generation over the next 15 years.

China has taken a multi-pronged approach to reducing fossil fuel dependence. Consider solar energy. The country has had inexpensive solar systems for heating water for bathing and washing for many years. In 2006 about 30 million Chinese households had such as system, and their popularity has increased dramatically since then. While these systems are popular in other countries also, China alone generated more than half of the 172 GW of solar thermal power used worldwide in 2009. Often the hot water storage tanks, and occasionally some other components, are made of nickel-containing Type 304 stainless steel (S30400).

Solar photo-voltaic (PV) cells produce electricity and, while the costs are still relatively high, recent technological developments combined with mass production have resulted in a great reduction in those costs. In late 2011 China increased its goal for 2015 by 50% for installed PV capacity to 15 GW. While stainless steels are sometimes used for substrates and other components,

Above from left to right:
Solar water heating systems on the roof of a residential building; Methane production plant; Concentrated Solar Power; Solar photo-voltaic cells.

they are primarily needed to make the solar cells themselves. In Golmud in Western China, for example, there was a total of 570 MW of electricity produced from solar parks in 2011, with 500 MW more expected in 2012.

A third technique, Concentrated Solar Power (CSP), involves focussing solar radiation through lenses or by mirrors onto a small area. The heat powers boilers and the resulting steam drives turbines to produce electricity. At present there are at least eight projects either planned or under construction in China, ranging from small 1-MW pilot projects to 2,000-MW mega projects. Owing to the high temperatures involved, stainless steels and sometimes nickel alloys are required. Further development is needed to prove the commercial viability of this technology, and China is one of the leading countries here also.

Bio-energy is another energy source that is both in use currently and undergoing rapid improvement. Methane is produced from animal and human waste using small-scale installations, especially in rural areas, where it is used mostly for cooking and lighting. Similarly, waste animal fats are often used to produce biodiesel. Although China is the third-largest producer of ethanol in the world, its 2011 production of 2.2 billion litres was much less than either Brazil or the U.S. Much of the ethanol ends up being used in gasoline as a 10% blend.

As in many countries, there is a vigorous debate about the use of purpose grown grains and sugar cane which can be used for food or bio-energy production. As a result, processes are being developed for using agricultural waste and other crops to produce ethanol or biodiesel. Stainless steels are typically used in all these processes. Further information on stainless use can be found in the Nickel Institute's new publication 10090 Stainless Steels: Cost-efficient Materials for the Global Biofuels Industries (downloadable from the NI website at http://www.nickelinstitute.org/en/MediaCentre/News/~/media/Files/TechnicalLiterature/StainlessSteels_CostEffectiveMaterialsForTheGlobalBiofuelsIndustries_10090.ashx).

It is energy that is fueling the growth of China, and China is working hard to find cleaner, more sustainable energy sources.

Other alternative sources of electricity in China include natural gas, water, nuclear fusion and wind, all of which carry some environmental impact. Nickel is found in materials used in each of these.

Coal firmly remains the primary fuel for the generation of electricity in China and will remain so for many years to come. It is important, then, to make the coal as environmentally friendly as possible. Processes for coal gasification have been around for years but are not generally cost-effective. Chinese researchers are working to improve the economics. In the meantime, much can be done to reduce emissions from standard coal-fired power plants by removing harmful pollutants such as sulphur dioxide, mercury, and particulate matter. Technologies, most of which use stainless steels and nickel alloys, already exist for these and are being used in modern plants in China.

It is energy that is fueling the growth of China, and China is working hard to find cleaner, more sustainable energy sources. Ni

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Waste Not:

Stainless Steel Supporting Farmers

All food producers, from the smallest fair-trade farmer to the largest agri-business, face a similar major challenge as they seek to maximize their output and feed the planet. It is not drought or pests or even disruptions caused by wars or political unrest.

It is waste.

The United Nations Food and Agriculture Organization (FAO) estimates that a third of the food produced for human consumption – a staggering 1.3 billion tonnes – is spoiled during harvesting, processing, storage, or transportation to market, or else is thrown away. While consumers are the worst culprits in the industrialized world, an FAO study released in 2011 found that, in the developing world, most wasted food is lost or spoiled in the early stages of production – more than 150 kilograms per person per year in Africa, Asia and Latin America combined.

> The AMTEC recommend Type 304 stainless steel for the pulping mechanism and chamber, and Type 316 for the outlet that dispenses the exposed bean.

Two of the solutions the FAO advocates are better education and co-operation among small-scale farmers and improving access to the tools that are needed to process crops safely,

cheaply and efficiently. Their recommendations are for basic foodstuffs as well as cash crops including export commodities such as coffee, cocoa and sugar.

The Indonesian Coffee and Cocoa Research Institute, based in Jember, near the eastern tip of the island of Java, promotes efficiency in harvesting and processing. Low-acidic cocoa beans can be produced, the institute notes, using a small mechanical pulp reducer powered by a 5.5-horsepower engine. After the pods are split, the pulp-covered beans are fed into a static sieve-lined stainless steel drum, 300 millimetres in diameter and two-thirds of a metre long. Fast rotating stainless steel agitators inside cause much of the pulp to rub off against the sieve and be removed. With less pulp on the beans they can be fermented quicker. The removed pulp can then be used to make beverages or to promote bacteria growth during the composting of the cocoa pods. The machine can process two tonnes of beans per hour and produce up to 150 kilograms of pulp per tonne.

Cocoa production is a mainstay for an estimated 800,000 rural families in Ghana and accounts for a third of the country's exports. Researchers at the Ghana University of Mines and Technology have recently designed a machine to split open the tough pod that surrounds the cocoa beans, a laborious task usually done by hand with the aid of a machete or a knife. The design specifies the use of martensitic stainless steel cutting blades with a high chromium content to ensure hardness and corrosion resistance. The box-like machine promises to boost quality and productivity. Moreover, it is simple and cheap to assemble, putting it within the reach of rural farmers.

Among South Africa's chief exports is raw sugar. Sugarequip (Pty) Ltd., a local engineering firm, builds and supplies equipment to process sugarcane and, in doing so, makes extensive use of stainless steel components to reduce downtime caused by breakdowns and worn-out parts. Stainless steel, for example, is one of the materials specified for centrifuge mesh screens and filters. Also, seed cane can be heat-treated in a tank made from corrosion-resistant 3CR12 (S41003) to prevent the spread of disease. Meanwhile Type 304L (S30403) is used in the fabrication of polybaffle entrainment screens which are designed to recover sugar from exhaust vapour which would otherwise be lost during processing. Sugarequip has also developed a raw sugar boiling pan system that employs a series of stainless steel electrodes to control and monitor processing. Installed in a Sudanese plant, it has been found to boost quality and reduce both processing time and the amount of sugar wasted.

Stainless steel is also used to process sugarcane in modest-scale operations. In the Indian city of Chennai, Four Brothers Eximp Pvt Ltd manufactures food-processing machines for farm and domestic use in remote areas under the brand names RAJA, AMUDA and BOSS. All components of the firm's hand-operated cane crusher that come into contact with the cane are built from stainless steel, including rollers made from Types 304 (S30400) or 316 (S31600). Four Brothers' products, which include manually operated machines to remove pulp from coffee beans, are used throughout Africa and Southeast Asia, particularly by small-scale farmers in areas without electricity.

In the Philippines, draft standards recently developed by the Agricultural Machinery Testing and Evaluation Center require food-grade and non-corrosive materials to be used for all components of motorized and hand-operated pulpers that come into contact with coffee beans. The standards, which would apply to all machines, whether imported or domestically made, recommend Type 304 stainless steel for the pulping mechanism and chamber, and Type 316 for the outlet that dispenses the exposed bean. The goal is to ensure a minimum bean-recovery rate of 93.5% with 98% purity.

Bogota, Colombia-based Ingesec-Promain Ltda, a manufacturer of coffee-processing machines, makes extensive use of stainless steel in its line of Gaviota pulpers and Belcosub processing units. Developed in partnership with Colombian coffee growers, the machines are sold throughout Central and South America and as far afield as Ethiopia and Indonesia. The pulper features a stainless steel screw conveyor which ensures uninterrupted flow and can process the coffee fruit at rates of up to 2,500 kilograms per hour. The more elaborate Belcosub machine, electrically powered but still designed for processing at the farm level, also features a stainless steel screw-feeding mechanism with a stainless steel casing. It is designed to produce more and better-quality coffee using less water.

When food is wasted, the FAO study warns, "huge amounts of the resources used in food production are, in effect, wasted as well." And for small-scale farmers in developing countries who already live "on the margins of food insecurity," more efficient handling and processing of food are sure to reduce losses and improve their livelihoods. Ni

Machines clockwise from top left:
Coffee pulper: *http://blog.juanvaldez.com*
Hand operated sugar cane crusher : *http://www.fourbrothersei.com*
Screw conveyors: *www.ingesecltda.com*
Gaviota 1200: *www.ingesecltda.com*

ISTOCK PHOTO © MICHAŁ RÓŻEWSKI

Toxicological Triage: Effective Economical Ethical

Toxicological testing is necessary, expensive and increasing in scope. It also implies ever more animals will be needed as surrogates for human exposures. Finding ways to make the process more efficient as well as to reduce the need for animal testing is a high priority. One technique directly relevant to metals and alloys and of increasing importance is bio-elution.

More chemicals = more testing

Industry is very good at producing new chemicals, new combinations of chemicals, and new uses for them all. All require testing for their human and environmental impacts, a need that has become more demanding over time as it became clear that mixtures and alloys do not necessarily have toxicological profiles that are the sum of the properties of their constituent elements.

Yet not all chemicals will present the same hazards. Anything that has the potential to reduce the number of chemicals, mixtures and alloys that need to be taken through a full toxicological test regime will be of great interest.

This is relevant to nickel because the toxicological profiles of many hundreds of nickel-containing alloys and additional hundreds of nickel-containing chemicals and mixtures need to be determined.

Bio-elution and screening

The idea of grouping mixtures and alloys into groups or families of substances with predicted similar toxicological profiles is not a new one. It is a first-order way of getting a grip on the tens of thousands of substances that need to be assessed and for setting priorities for testing. Within those groups, however,

UNS details

Chemical compositions (in percent by weight) of the alloys and stainless steels mentioned in this issue of *Nickel*.

	Al	C	Cb	Cr	Cu	Fe	Mn	Mo	N	Ni	P	S	Si
S30103 p. 5		0.030 max		16.00-18.00			2.00 max		0.2 max	6.0-8.0	0.045 max	0.030 max	1.0 max
S30153 p. 5		0.030 max		16.00-18.00			2.00 max		0.07-0.20	6.0-8.0	0.045 max	0.030 max	1.0 max
S30400 p. 5, 10, 13, 16		0.08 max		18.00-20.00			2.00 max			8.00-10.50	0.045 max	0.030 max	1.00 max
S30403 p. 13		0.03 max		18.00-20.00			2.00 max			8.00-12.00	0.045 max	0.030 max	1.00 max
S41003 p. 13		0.030 max		10.50-12.50			1.50 max		0.030 max	1.50 max	0.040 max	0.030 max	1.00 max
S31600 p. 13, 16		0.08 max		16.00-18.00			2.00 max	2.00-3.00		10.00-14.00	0.045 max	0.030 max	1.00 max

What is needed are screening procedures that will sort out the low hazard materials from the potentially problematic

there will be variations and perhaps even some surprises. Thus looking at nickel-containing alloys, mixtures or chemicals as being similar on the basis of them having a similar nickel content is not a rigorous or sufficient approach for hazard assessment or classification.

What is needed are screening procedures that will sort out the low hazard materials from the potentially problematic and can be used as the starting step in grouping substances and for reading across of toxicity profiles within each group. In addition to the financial and human resource efficiencies, it holds the potential of greatly limiting the necessity of using animals. This is the promise of bio-elution testing.

Bio-elution methods measure what comes out of a sample of material placed in a container with artificial solutions that mimic the fluids of the human body. The interaction between a substance and, for instance, a solution that mimics gastric juices will result in the release of some material into that solution. The numbers of metal ions freed will vary greatly between a metal and the various alloys and compounds that include that metal as a constituent.

The assumption is that the higher the number of ions released the greater the potential for adverse metal-related health effects associated with the route of exposure relevant to the fluid tested. The variations between different materials point to which of them may be candidates for additional testing.

Advantages

Bio-elution assays are inexpensive, easy to set up, and quick. There is a role for animals only at the developmental stage where testing is needed to verify an assay's reliability for each particular application before it can become an acceptable screening tool.

Large numbers of materials can be screened in a short period of time. The assays are flexible and can be tailored to examine different routes of exposure of interest such as skin contact, inhalation or ingestion. An important consideration is the ability of different laboratories working with the same materials to produce identical or very similar results.

In addition to finished products, complex materials commonly seen in occupational settings such as ores, concentrates and intermediates can be tested using the same technique. Comparisons can be made between the toxicological profile of the constituents of the material and the material itself. Comparisons between the releases of metal ions observed can predict their toxicological profiles and identify candidates for further testing.

The results are typically conservative since not all metal ions released in a beaker will be available for absorption in an intact organism. In other words, the potential for the release of metal ions is maximized in ways that are unlikely to occur in human exposures. This means that the signals given by bio-elution assays will lead to marginal materials being referred for further testing and overall results that are more protective of human health.

Nickel examples

The most widely known toxicological issue associated with nickel is nickel allergic contact dermatitis (NACD). In the case of nickel dermatitis there has been over two decades of experimentation and refinement of a bio-elution technique. The same solution is part of the test assay (EN1811:2011) used for a European Union Regulation that established the permitted amount of nickel that may be released by consumer products intended for direct and prolonged contact with the skin. As a result, literally thousands of such articles covered by the Regulation are now safer for consumers.

While other bio-elution applications have not yet been adopted into the regulatory framework, they are increasingly accepted as practical tools for toxicological screening for human health. One such example is the recent publication of two peer-reviewed papers on the results of a bio-elution-based read-across research program to fill data gaps for 12 nickel-containing chemicals that were registered on behalf of the Nickel REACH Consortia*.

Henderson RG, Durando J, Oller A, Merkel DJ, Marone PA, and Bates HK. 2012. Acute Oral Toxicity of Nickel Compounds. Regulatory Toxicology and Pharmacology, Volume 62, Issue 3, April 2012, Pages 425-432. http://www.sciencedirect.com/science/article/pii/S0273230012000219

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This article is based on a 2011 entry submission to EPAA (European Partnership for Alternative Approaches in Animal Testing) written by Violaine Verougstraete (Eurometaux), Katrien Delbeke (European Copper Association), Rayetta Henderson (NiPERA), and Adriana Oller (NiPERA).

Stainless 'Sprouts' Symbolize India's Rebirth

New Delhi is full of impressive reminders of India's proud history. Like other ancient civilizations, major historical phases are visible in its buildings and public art, including early forts and palaces, the Parliament buildings inherited when India gained its independence in 1947, and glittering modern buildings.

Important stages in India's history may be said to have emerged like plants springing from the earth.

Vibhor Sogani, a New Delhi-based contemporary artist and designer, sought to symbolize this idea of historical birth and rebirth in his first major public art installation "When Seeds Begin to Sprout," which covers a 2.4-hectare (6-acre) lawn on both sides of the All India Institute of Medical Services (AIIMS) flyover crossing (overpass) in Delhi. 120 glimmering "sprouts" emerge in clusters from soil that has been reshaped into gentle rolling mounds. Like the springtime that inspired his creation, Sogani says the installation is symbolic of India's shining rebirth after 60 years of independence.

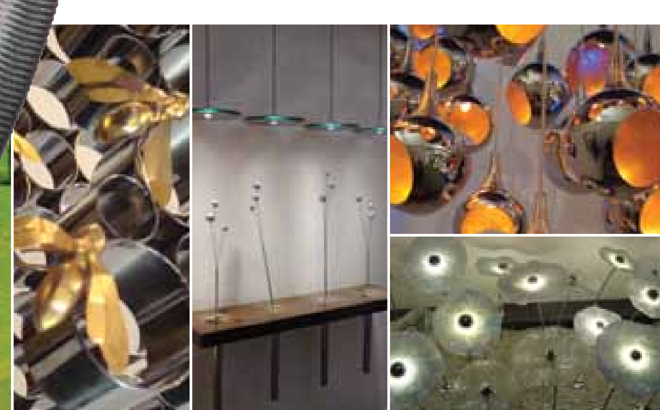
Glittering stainless steel was selected to symbolize this. Mirror-polished globes of Type 304 (UNS S30400) stainless steel are lifted off the ground and supported by curved polished stainless steel pipe "stalks." The top of each stalk is wrapped in Type 316 (S31600) stainless steel cable which creates a transition and supports the globes in cone-like cradles with visible welding lines that cause them to resemble sprouts. Each sprout is between 6 and 11 metres high, and within the clusters of up to 8 sprouts, the stalks are bent in different directions. The public art installation was sponsored and paid for by Jindal Stainless Ltd.

Sogani is well-known for exploring the qualities of stainless steel and how they can be visually combined with other materials such as stone, copper alloys, and iron. He has won accolades for unique lifestyle products such as elaborate light sculptures, chandeliers and furniture. His sculptures can be found in private residences, corporate offices, and other diverse interior and exterior spaces. Creative application of stainless steel is a trademark of his work. Ni

PHOTOS: STUDIO VIBHOR SOGANI

◁ *Left: **Sprouts** 12 metre high installation, in the 2.4-hectare (6-acre) of green space which lie between the flyovers at AIIMS crossing, Delhi. This project is in collaboration with Jindal Stainless Ltd.*

▽ *Below: decorative lights by Studio Vibhor Sogani. **Beehive**, **Aura Neo**, **Chroma**, and **Tulips***



PHOTOS: CATHERINE HOUSKA