NICKEL

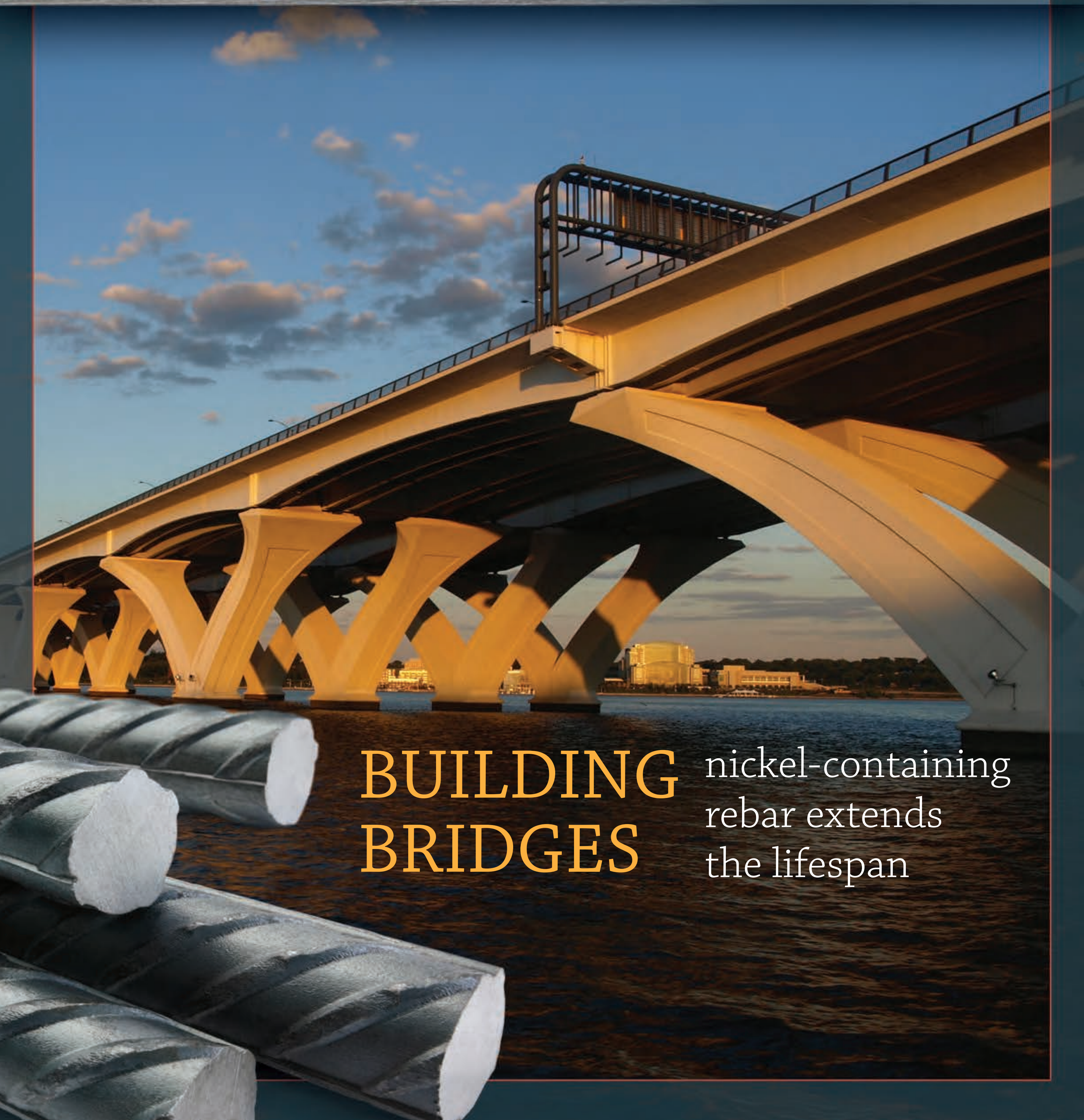
THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

April 2016, Vol. 31, No 1

Stainless steel rebar for bridges that last

Building strong structures

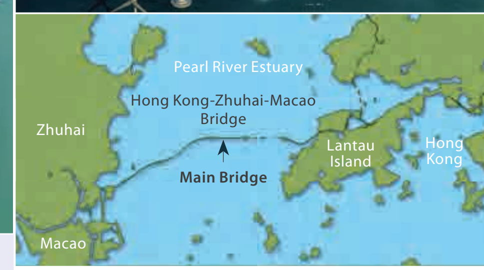
Nickel lights up remote communities



BUILDING BRIDGES

nickel-containing rebar extends the lifespan

△ *The main section of the bridge* △ *The Hong Kong-Zhuhai-Macau bridge under construction*



△ *Artificial island and approach for the tunnel section*

△ *The main bridge will extend for 29.6km over the Pearl River Estuary.*

CASE STUDY 06
HONG KONG-ZHUHAI-MACAU BRIDGE

The Pearl River Delta (PRD) in Guangdong province is one of the main hubs of China's economic growth. The industrial cities of the PRD have been called the "Factory of the World" and the Pearl River Delta Economic Zone (PRDEZ) accounts for approximately one third of China's trade value. The PRD is also one of the most densely urbanised regions in the world with a combined population of around 57 million in the nine largest cities of the region which include Hong Kong, Zhuhai and Macau.

The PRDEZ is divided by the Pearl River Estuary. Road transport between the east and western sides currently involves a 200km journey via the Humen Bridge located to the north. The governments of Hong Kong, Macau and Guangdong are now building a bridge over the estuary to provide a direct link for passengers and freight, alleviating the heavy traffic congestion at the Hong Kong-Shenzhen frontier checkpoints and reducing the economic losses arising from the daily hold-up at these border crossings.

The Hong Kong-Zhuhai-Macau Bridge will link Hong Kong to Macau and the city of Zhuhai in Guangdong province. The main bridge will extend for 29.6km from Macau over the western portion of the Pearl River Estuary. It will land on an artificial island which is connected to another artificial island by a 6.7km long underwater tunnel. The bridge then continues to mainland Hong Kong creating a combined bridge and tunnel structure. The bridge's dual three-track highway will reduce travel time between Hong Kong, Macau and Zhuhai from four hours to just 30 minutes. Ni

THE LONGEST SEA BRIDGE IN THE WORLD

The Hong Kong-Zhuhai-Macau Bridge is one of the world's major infrastructure projects. It will be the longest sea bridge in the world with total length of 50km. Nearly 10,000 tons of Alloy 2304 (UNS S32304) nickel-containing duplex stainless steel rebar, rod and wire have been specified to achieve its design life of 120 years. The Alloy 2304 components supplied by Taiyuan Iron & Steel Company (TISCO) will be used for the bridge bearing platform, tower foundation and pier shaft. This is the first time duplex stainless steel has been used in bridge construction in mainland China.

The total cost of the project is estimated to be US $10.6bn (70bn yuan), which is the largest investment in the history of Chinese bridge construction. Construction of the bridge commenced on 15 December 2009, and is currently due for completion in 2018.

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NICKEL

The Magazine Devoted to Nickel and its Applications

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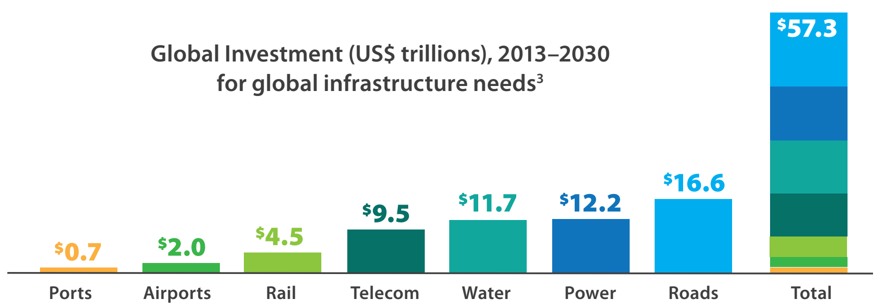
BUILDING THE FUTURE

When President Obama said, "Twenty-first century businesses need 21st century infrastructure",[1] he was voicing the concerns of governments across the world charged with replacing the many roads and bridges constructed in the last century which are now crumbling.

The numbers are stark: 65% of America's major roads are in 'less than good condition' and 25% of bridges require 'significant repair or can't handle today's traffic'.[2] In Germany, it is reported that over half of all autobahn bridges are urgently in need of repair. And in the UK, the Civil Engineering Contractors Association said in 2013 that the cost of infrastructure falling short of typical 'developed economy standards' amounted to £78 billion each year between 2000-10.



Most of us take for granted the infrastructure around us, and it is only when potholed highways, disintegrating bridges and decaying transit tunnels impact our daily commute, that we take notice.

Clearly, a long design life is desirable for infrastructure to minimise disruption as well as cost and nickel-containing constructions have a great track record. The Progreso Pier in Mexico is just one example of the benefits of nickel-containing stainless steel reinforcement bar (rebar) to enable infrastructure to withstand the test of time in harsh environments—over 70 years and counting in this case.

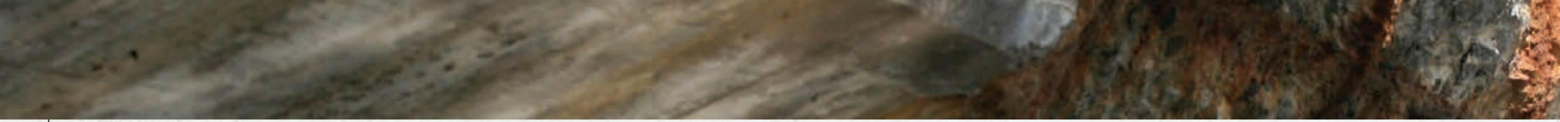
And now a new generation of mega projects is underway, including the Hong Kong-Zhuhai-Macau bridge featured opposite and the new Champlain Bridge to be built across the St. Lawrence River in Canada (page 4). Both bridges will make use of the corrosion-resistant properties of nickel-containing rebar.

This edition of *Nickel* looks at how nickel-containing rebar and other materials are contributing to bridges and quality construction. The nickel is hidden but its role in preventing corrosion of infrastructure is vital if governments and citizens are to get value for money with long lasting, fit for purpose bridges, roads and buildings.

Clare Richardson
Editor, *Nickel* magazine

[1] *State of the Union address, January 2015*
[2] *Report by US National Economic Council and President's Council of Economic Advisors, 2014*
[3] *Exhibit from "Infrastructure Productivity: How to Save $1 Trillion a Year", January 2013, McKinsey Global Institute, www.mckinsey.com. Copyright (c) 2013 McKinsey & Company. All rights reserved. Reprinted by permission.*

Nickel INSTITUTE
knowledge for a brighter future



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A solid solution to crumbling infrastructure

Corrosion-resistant stainless steel rebar

As our infrastructure ages, concrete deterioration has become one of the most costly and widespread problems. Why? According to Dr. Karen Scrivener, Head of the Construction Laboratory at the Swiss Federal Institute for Technology, corrosion attack on rebar is "the cause of over 90% of problems of concrete durability".*

And concrete structures that are exposed to de-icing salt, seawater or marine atmospheres are particularly susceptible to accelerated deterioration.

Getting inside the problem

Technically speaking, chloride ions, moisture and air (oxygen) migrate through the porous concrete cover and cause corrosion on the surface of the embedded carbon steel reinforcing bars (rebars). The resultant corrosion products (rust) occupy a greater volume than the steel from which they were formed. This increase in volume exerts pressure on the surrounding concrete and causes it to crack.

The cracks allow further penetration of chloride, moisture and oxygen down to the carbon steel—accelerating the corrosion process. Over time, the cracks enlarge and the concrete can spall.

Building stronger and longer—a remarkable example

In response to this growing problem, numerous laboratory tests and life cycle cost analyses have highlighted the benefits of using stainless steel rebar in order to achieve service lifetimes of 75-100 years without major repairs or rehabilitations.

The Progreso Pier in Yucatan, Mexico confirms these benefits. Completed in 1941, this two km-long reinforced concrete pier juts out into the Gulf of Mexico and is continuously exposed to a harsh tropical marine environment.

Recent concrete coring and detailed inspections have found the pier, constructed with nickel-containing Type 304 (UNS S30400) reinforcement, to be in excellent condition after 75 years of service—without any significant repair work.

▽ Life Cycle Assessment shows that the choice of nickel-containing rebar over 70 years ago has been a good investment for the Progreso Pier in Mexico

WIKIMEDIA COMMONS

MAJOR BRIDGE PROJECTS			
LOCATION	**YEAR**	**STAINLESS STEEL ALLOY/TYPE**	**TONNAGE (approx.)**
Michigan, USA Bridge on I-696, near Detroit	1984	304	33
New Jersey, USA Garden State Parkway	1998	2205	165
Ireland, Broadmeadows Bridge	2003	316	90
Oregon, USA Haynes Inlet Bridge	2003	2205	400
New York, USA Belt Parkway Bridge, Brooklyn	2005	2205	200
New Jersey, USA Driscoll Bridge	2005	2205, 316LN	1300
Virginia–Maryland, USA Woodrow Wilson Bridge	2007	2205, 316LN	1100
Hong Kong, Shenzhen Western Corridor Bridge	2007	2205, 316	1300
Hong Kong, Stonecutters Bridge	2009	304	3000
Rhode Island, USA Sakonnet River Bridge	2010	2205	800
Minnesota, USA Hastings Bridge	2010	2304	367
Minnesota, USA Lafayette Bridge	2011	2304	1963

Nickel's role in the answer

Alloy producers have made significant advances over the past two decades, developing and making commercially available a range of corrosion-resistant stainless steel rebars (together with stainless steel tie-wire and rebar couplers). In fact, for the past twenty years or so, the most frequently specified stainless steel rebars have been the nickel-containing alloys Type 316LN (UNS S31653) and two duplex grades, Alloy 2205 (UNS S32205) and Alloy 2304 (UNS S32304)—together with a smaller amount of Type 304.

By adjusting alloy compositions, stainless steel rebar producers have been able to achieve an optimal combination of corrosion resistance, strength and formability. Alloy 2304 represents an attractive combination of these important properties—at a competitive price. This combination has led to the alloy being specified for several large bridges in recent years.

The new alloys in action

Alloy 2304 was recently selected for the new Champlain Bridge to be built over the St. Lawrence River at Montreal, Canada. With a proposed span of approximately 3.4km (excluding approaches), it is estimated that this bridge will require about 15,000 tonnes of Alloy 2304 rebar.

All of the nickel-containing stainless steel rebars retain good tensile strength and impact resistance at sub-zero temperatures. These properties are important for highway bridges which must endure severe winters—together with the application of lots of corrosive road salt.

Additional applications

Rebars made from Type 316LN and Type 304 retain good mechanical properties down to

Chemistry World, Vol 5, No3 March 2008

INFRASTRUCTURE CANADA

△ *Spanning the St. Lawrence River in Canada, the new Champlain Bridge will contain 15,000 tonnes of Alloy 2304 rebar.*

△ *Alloy 2304 stainless steel rebar for the Hastings Bridge, Minnesota, USA project supplied by Contractors Materials Company*

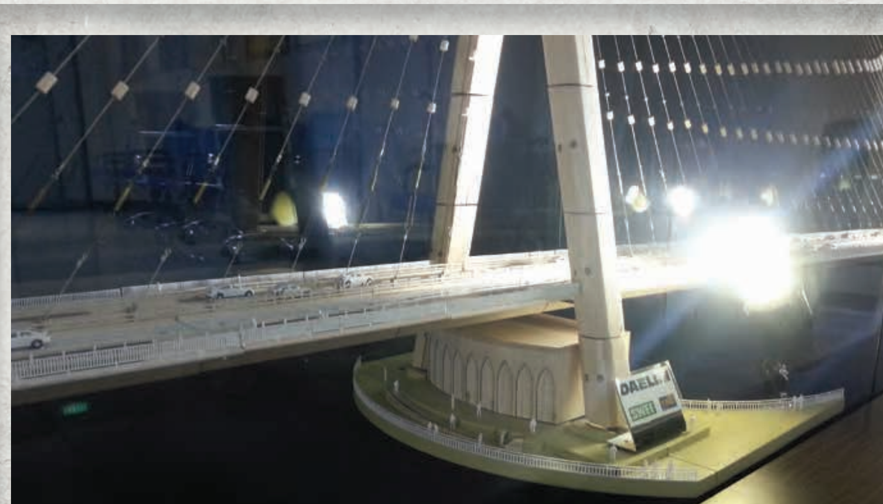
WWW.CMCMMI.COM

FRANK SMITH

△ *Stainless steel rebar samples: A reel of tie-wire (bottom left), a threaded rebar coupler (centre) and (top right) a tight U-bend illustrates formability.*

cryogenic temperatures which has led to their use in LNG storage facilities. Type 316LN is also a non-magnetic material and several hundred tons of this alloy rebar have been used in the construction of MRI facilities at hospitals and clinics—as well as for special laboratories and data storage facilities.

Longevity, corrosion resistance and strength reinforces the many uses of nickel-containing stainless steel rebar as a cost-effective, farsighted solution. Ni



©WWW.TESOLUTION.COM

△ *A model of the Temburong Bridge is wind tunnel tested by TESolution.*

TEMBURONG BRIDGE BRUNEI

Around 3500 tons of nickel-containing Type 304 (UNS S30400) stainless steel rebar will be supplied by TISCO for the US$ 1.6 billion bridge to cross Brunei Bay. The 'mega' bridge will connect the districts of Temburong and Brunei-Muara. These two districts are separated by Malaysian territory, and travel between them requires either a 1.5 hour journey by land crossing through Malaysia or 45 minutes by boat. The 30 kilometre bridge, which will consist of a dual two-lane highway is anticipated to cut travel time to about 20 minutes. Construction started in 2014 and the bridge is expected to be completed by 2019. Ni

EUGENIO MERZAGORA (WWW.STRUCTURAE.DE)

△ *Schaffenhauser Bridge was designed with an 80 year lifespan*

The new Allt Chonoglais bridge under construction △

Original Allt Chonoglais Bridge prior to demolition and showing signs of rebar corrosion ▷

Longer lifetimes for major bridges

Marginally higher initial costs for stainless steel results in much lower life cycle cost

The use of nickel-containing stainless steel rebar in bridges worldwide has been growing—although perhaps not as quickly as motorists wish when queuing impatiently while a lane or two of a bridge or elevated roadway is being dug up and repaired. The relatively quick corrosion of carbon or epoxy coated rebar results in cracking of the concrete and thus the need for major maintenance, leading to blocked off lanes of traffic while the concrete is removed and the rebar replaced. Today, transportation authorities are increasingly factoring in the indirect costs to society of traffic delays (wasted fuel, wasted time) as well as environmental costs (air pollution, landfill costs) when specifying construction materials. This holistic thinking makes the selection of stainless steel even more clearly justifiable.

Even without considering these less tangible factors, stainless steel is the best choice in many cases when looking at costs over the life of the bridge. When the Schaffhausen Bridge, which spans the Rhine in Switzerland, was planned in the mid-1990s, the design called for it to have an 80-year life with minimal maintenance and no loss of structural integrity. The use of conventional reinforcement materials, either coated or plain carbon steel, would mean major repairs roughly every 25 years, whereas the use of Type 304 (UNS S30400) stainless steel rebar would meet the 80 year criteria. By the selective use of stainless steel, the total cost of the bridge was increased by only 0.5%. Significant savings can be realized after only 25 years when stainless steel is used, with even greater savings accumulating over the life cycle of the structure. If this bridge had higher road salt loadings, or was near to seawater, a higher alloyed rebar material such as Alloy 2304 (S32304), Type 316L (S31603) or even Alloy 2205 (S32205) may have been needed, and that too would have only added marginally to the cost of the project. Many factors can affect the amount of chloride that will reach the rebar, including cement type, depth of cover, and water/cement ratio. This means that not all rebar in the structure needs to be in stainless steel. Rebar positioned deeper in the structure, or not otherwise exposed to higher levels of chlorides can be supplied in the lower cost unalloyed steel. Using a combination of stainless steel in the top layer and carbon steel in a lower layer of a bridge deck is a common practice. Tests have shown that galvanic corrosion is not an issue here.

> Significant savings are to be had using stainless steel after only 25 years, with even greater savings extending well into the future.

Today, designers are specifying longer lifetimes for major bridges, as great as 125 years. The initial cost of some bridges may be a few percent higher with the selective stainless steel option, but in all cases, results in much lower life cycle cost.

The Allt Chonoglais bridge near Orchy, Scotland is a more recent example of stainless steel rebar use. The old bridge was found to be under strength for the future loads it would carry, and could not be economically repaired. De-icing salts over time had caused corrosion of the carbon steel rebar resulting in cracking of the concrete and leading to a reduction in structural integrity. A new and stronger structure was engineered with

OUTUKUMPU

△ *Stainless steel reinforcement having been fully cut and bent at Outokumpu's Sheffield Stainless Bar facility for the new Allt Chonoglais bridge*

a requirement for a design life of 120 years. After considering the expected chloride levels over its lifetime, the Highways Agency and Transport Scotland chose Alloy 2304 (S32304) stainless steel for selected areas, such as the bridge deck, abutments, wing walls and bearing plinths. The total cost of the construction was £1.8 million (about US$2.5 million) with the new bridge open to traffic in August 2013. In 25 years or so, motorists driving on the A82 between Glasgow and Inverness will appreciate the forethought given by the Scottish engineers for using a nickel-containing stainless rebar that will last the 120 design life of the bridge. Ni

Navy Pier Point Loma

All steel hulled sea-going vessels pick up a magnetic signature as they travel the globe. For naval vessels, this magnetism can be detrimental, as it can be used by enemy magnetic mines and other magnetic sensing equipment to identify and destroy them. Many navy vessels therefore undergo a deperming operation (also called degaussing) that removes that permanent magnetism and helps to camouflage them. The pier where this operation takes place should show no magnetic response either, hence the need for nickel-containing austenitic stainless steels. When the U.S. Navy selected concrete reinforcing (rebar) and stranded wire for their pier at Point Loma, San Diego, California, they used both Type XM-29 (UNS S24000) and Type 304 (S30400) stainless steel. The chosen alloys in the pier had to withstand the effects of the Pacific Ocean salt water diffusing into the concrete combined with warm temperatures. The magnetic permeability of Type XM-29 remains very low even after severe cold working, so the pre-stressing strand used in the square piling, pile caps and in the deck were also of this alloy. Where the stainless steel strand was only lightly stressed, Type 304 was used. In 2008, after 20 years of service, an inspection was made of the whole structure. The only minor corrosion found was on the Type 304 stainless steel where there had been insufficient concrete cover (less than 12mm). Where there was 25mm or greater cover, the Type 304 and all the Type XM-29 was found to be in excellent condition. Similar piers have been constructed at King's Bay, Georgia and Pearl Harbour, Hawaii. Ni

▽ *Point Loma*

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KILLION O'SULLIVAN

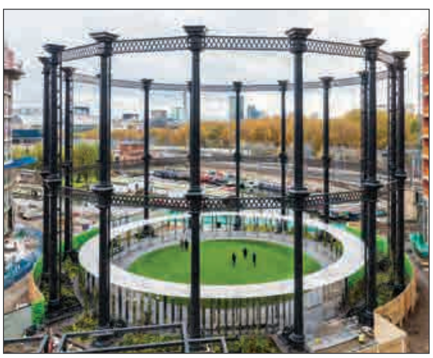
Stainless steel takes the strain

The role of nickel-containing stainless steel in load-bearing applications

Stainless steel is a highly versatile material, possessing a unique selection of useful properties which can be exploited in load-bearing applications. The main property distinguishing stainless steel from carbon steel is its inherent corrosion resistance, due to the tightly adherent protective layer of chromium oxide which spontaneously forms on its surface in the presence of oxygen. This means that stainless steel components can be exposed to a wide range of environments without the need for protective coatings and is ideal for projects where an exposed metallic finish is required.

Due to differences in chemical composition, a stainless steel structural member subjected to a fire behaves differently than a carbon steel member: stainless steel loses strength at a slower rate for temperatures above 500°C and retains its stiffness better at all temperatures. Because of excellent ductility coupled with significant strain hardening behaviour, stainless steel can absorb considerable impact without fracturing. This has led to its use in structures and equipment required to resist extreme loading, such as fire and blast walls for the oil and gas industry as well as security walls, barriers, doors and gates. The corrosion resistance of stainless steel makes it ideal for components in aggressive environments which are inaccessible or difficult to inspect, maintain or replace. For this reason, stainless steel is a popular choice for load-bearing components in the nuclear industry. Here we take a look at some recent diverse uses of stainless steel in structural components.

◁▽ Stainless steel canopy at Gasholder Park, close to King's Cross, London, UK



JOHN STURROCK

▽ Steel-concrete-steel test specimen prior to concreting (carbon steel plate on the left, stainless steel plate on the right)

VTT

▽ Stainless steel fire and blast walls were installed on the Arkutun Dagi platform

MTE LTD

Gasholder Park

Gasholder No. 8 was constructed in the 1850s. Part of the largest gas works in London, UK, it became a well-known landmark until it was decommissioned in 2000. The 25m tall guide frame was dismantled in 2011 and refurbished before being re-erected in 2013. To provide an interesting contrast to the gasholder frame, Architect Bell Phillips designed a 30m diameter polished stainless steel circular canopy within the perimeter of the frame. The canopy is supported by 150 columns, made from 25mm thick mirror polished 316L (UNS S31603) stainless steel, containing around 10% nickel. The columns are positioned at a wider spacing near the canal to encourage people to enter the park and give unobstructed views towards the canal. Away from the canal, the columns are closer together, creating a greater sense of enclosure. The canopy roof is 15mm thick 316L stainless steel plate, and incorporates a geometric pattern of perforations, formed by water jet cutting. The perforation density increases towards the canal to create a sense of openness, and a dappled effect as sunlight filters through.

Bearing the load in the nuclear industry

Load-bearing steel-concrete-steel modular structural units in new nuclear power plants are a popular choice, speeding up construction, simplifying the attachment of equipment support points and reducing costs. When one side of the unit is exposed to a corrosive environment, modules with a carbon steel plate on one side and a stainless steel plate on the other present an economic solution and have been used in the Westinghouse AP1000 pressurised water reactors in China and the US (Sanmen 1 & 2, Haiyang 1 & 2, Vogtle 3 & 4).

Although design codes for modular steel-concrete-steel construction in nuclear power plant exist in Japan, South Korea and the USA, there is no code in Europe. This is being addressed by a major EU-funded project led by the UK's Steel Construction Institute. The SCIENCE project, due for completion in 2017, includes tests on 9m long beams where one plate is carbon steel and the other 10mm thick Type 304L (UNS S30403), stainless steel which contains about 10 % nickel.

Blast resistant

Nearly 300 tonnes of Alloy 2304 (UNS S32304) duplex stainless steel (containing 4% nickel) were used in the fabrication of 13,400 m^2 of fire and blast walls, heatshields, wind walls and blast relief panels for the Arkutun Dagi development. This is one of three offshore fields developed by the Sakhalin-1 project, which has combined reserves of 2.3 billion barrels of oil and 17.1 trillion cubic feet of gas. Sakhalin is a remote, sparsely populated island in the icy Okhotsk Sea, just off the east coast of Russia. The fire and blast walls are lightweight, high integrity, fully welded, gastight systems manufactured from profiled stainless steel and insulated to achieve specified fire ratings up to H120 and 120 minute jet fire, and to resist blast pressures up to 1.5 bar. The walls were designed, engineered and manufactured by MTE Ltd in Darlington, UK before being shipped to South Korea, for final assembly. ExxonMobil started production at the Arkutun Dagi field in January 2015.

These are just some examples of how the versatile nature of stainless steel is providing solutions for a wide range of structural challenges. Ni

△ *Architecture students in Poland take part in a stainless steel workshop hosted by Stowarzyszenie Stal Nierdzewna (SSN), the Polish Stainless Steel Development Association.*

PHOTOS MDN MEDIA – AG WAGNER

Inspiring students

A new 'pick and mix' university course for students has been produced by experts from the stainless steel industry. The course aims to inspire university students of architecture and engineering with the multiple possibilities and advantages of stainless steel in the building and construction sector.

"The capability of stainless steel to provide an attractive and sustainable alternative to other construction materials is not usually taught to architecture and civil engineering students during their studies," says Bernard Heritier of the International Stainless Steel Forum (ISSF). "As a result, architects and civil engineers are not aware of the benefits, applications or design considerations specific to stainless steel. Instead, they are likely to hold the simplistic view that stainless steel costs more than carbon steel!"

The main reason for stainless steel being excluded from university curricula according to Heritier is the lack of time for course preparation and available teaching time. To answer the problem, the ISSF together with a panel of experts from academia and industry, have compiled a comprehensive and concise course aimed to help university lecturers educate students and young civil engineers about the use of stainless steel. Lecturers can use the course in its entirety, or pick and choose the parts that fit their curriculum.

The course covers 11 categories, divided where appropriate into more detailed sections. It has been fine-tuned over the past couple of years by a panel of university academics whose feedback has been incorporated into the overall product.

Topics range from stainless steel in art, to applications such as facades, green walls, urban furniture and water distribution. The corrosion and mechanical properties of stainless steel structural applications, stainless steel surfaces and finishes, joining and fabrication as well as sustainability are all covered.

The course is being used in a variety of ways. Some use the material in tutorials, others are using it for internal training and also as a reference guide as there is a useful list of sources at the end of each chapter. John Tarboton of the Southern Africa Stainless Steel Development Association is an enthusiast. "We present a condensed version to all fourth year architectural students around the country and use the material in specialised workshops, for example on stainless steel in structural applications."

The course, *Stainless Steels for Lecturers and Students of Architecture and Civil Engineering* is available for free download from:
www.nickelinstitute.org or *www.worldstainless.org/training/*
It is published in French and English with other languages planned. Ni

NI TECHNICAL HELP

ask our panel of experts

Anyone with specific questions about nickel and nickel-containing materials, including stainless steel, can contact the Nickel Institute's free Technical Help service. Expertise is provided by a worldwide network of highly qualified specialists, offering technical knowledge about nickel, its properties and uses to ensure optimum performance, safe handling and use. In addition, the service enables users to understand the benefits of nickel-containing materials and to use them cost effectively for appropriate applications with successful outcomes.

In 2015, around 500 inquiries were received and answered. Inquiries were received for a variety of end-use sectors including Engineering (36%); Architecture, Building and Construction (14%) and Chemical & Petrochemical (9%).

To access the service go to *www.nickelinstitute.org* and click on Technical Help. Ni

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Nickel-containing stainless steel
makes light work of brick soffits

HAWORTH TOMPKINS ARCHITECTS AND KEITH HUNTER

Behind a beautiful façade, a significant contribution is made by fixings and fasteners. Innovations in nickel-containing stainless steel fixing products are helping to accelerate the rate of construction and reduce build costs.

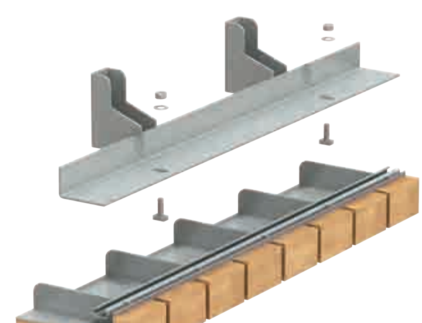
Brick soffits and reveals (the area of cladding that extends out from, for example, recessed windows) are an increasingly popular design feature on buildings adding an extra dimension to the masonry façade. Now stainless steel prefabricated units are removing the need to build complicated, time-consuming masonry soffits on-site and creating the desired look for a new building quickly and easily.

Fixing products provide critical connections within a building or structure, and are permanently under load. They are invisible once installed, and inspection, maintenance or replacement is often impossible due to inaccessibility or impractical due to the substantial costs and inconvenience it would involve. Therefore, nickel-containing stainless steel provides a long-lasting solution over carbon or galvanised steels in these structural applications.

Ancon Building Products, headquartered in Sheffield, UK, designs and manufactures a wide range of stainless steel fixings for brick and concrete construction. They have come up with an innovation in partnership with cut-brick specialist Ibstock Kevington to produce a quick and simple solution to creating flawless brick soffits for masonry building façades. "The advanced lightweight modular design makes it quicker to create brick soffits and achieve perfect alignment with the main brickwork façade," explains Ancon's Divisional Manager, Lisa Kelly.

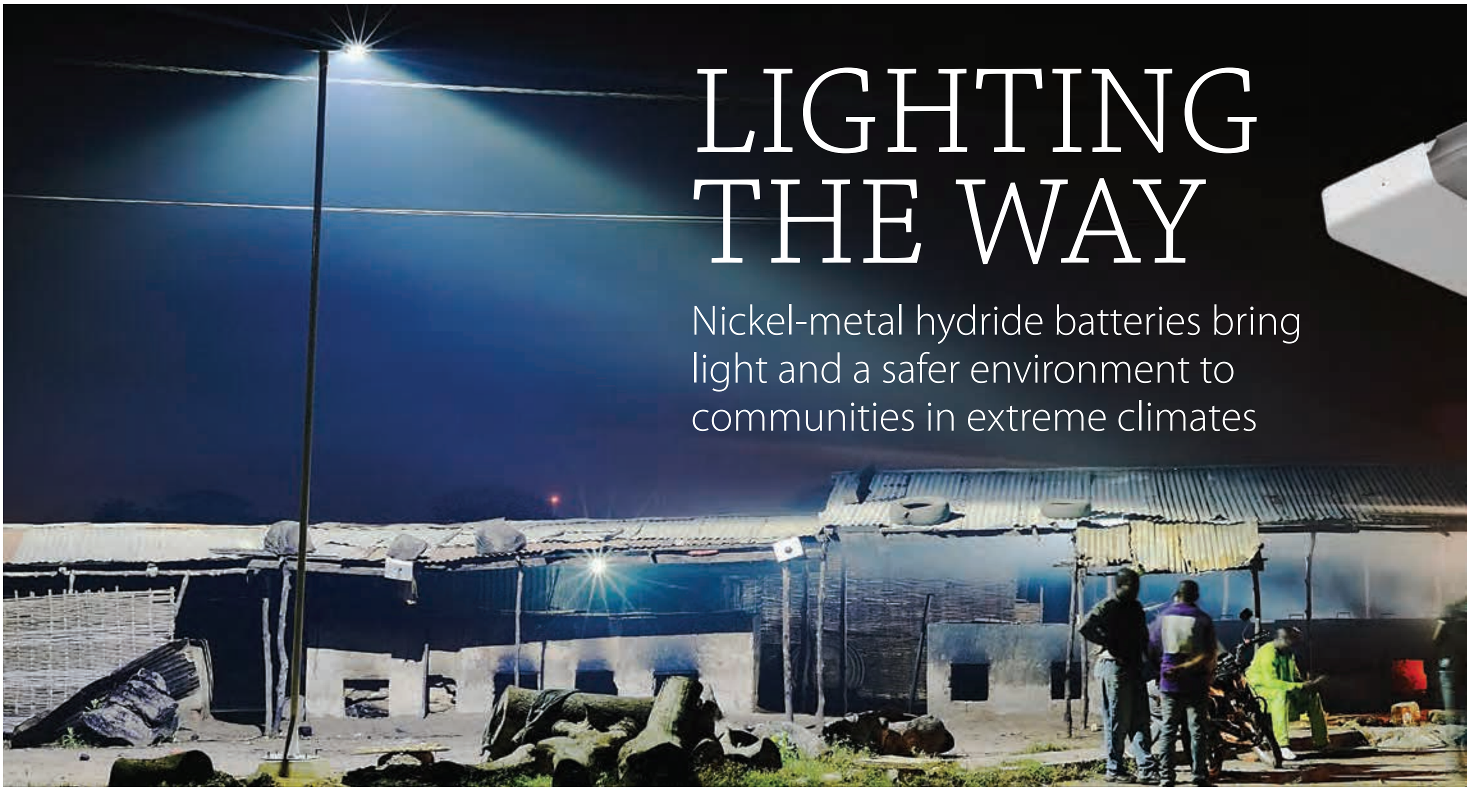
The Nexus® system combines a stainless-steel-backed brick-faced building module with a Type 304 (UNS S30400) stainless steel brick support angle. The lightweight stainless steel backing to the brick-faced unit offers considerable benefits over the more traditional cast concrete alternative. The new Nexus soffit system has about half the weight of concrete, which in most cases will allow the units to be installed without specialist lifting equipment. This offers significant savings in installation time, making it particularly appropriate for today's fast-track construction. Ni

△ *The new Nexus system has been used extensively in reveals on the Silchester Estate redevelopment, in Kensington and Chelsea, London, UK.*



ANCON BUILDING PRODUCTS

△ *The Nexus system combines a Type 304 (UNS S30400) stainless-steel-backed brick-faced building module with a stainless steel brick support angle. Individual units are prefabricated and made to measure off-site. They are simply offered up by hand to the pre-fixed and pre-drilled support angle and then bolted into position. This simple two-part design allows units to be installed and adjusted easily, creating perfect alignment, and once in position the brick slips are simply pointed to match the main brickwork façade.*



FLORIAN COAT

LIGHTING THE WAY

Nickel-metal hydride batteries bring light and a safer environment to communities in extreme climates

Achieving consistent and reliable street and open air lighting in areas of the world without a grid system is a considerable challenge and especially so in extreme climatic conditions. Yet the benefits in terms of safety and security for citizens, are immense.

Sunna Design, a French designer and manufacturer of solar lighting, is tackling this problem with a range of lighting solutions adapted for rural, arid or desert regions where installation and on-going maintenance are difficult. Sunna has developed lamp posts topped with solar panels which are equipped with a nickel-metal hydride (NiMH) battery, coupled with a smart energy management system. The lamps provide public lighting in remote areas which is essentially maintenance free, designed to limit vandalism and quick and simple to install.

For stand-alone solar lighting systems, a light weight battery can be an important advantage when set at height. Small NiMH batteries are integrated inside the head of the lamp and placed at the top of a mast. This significantly simplifies installation and avoids both having to bury the battery in the ground, as well as the need for cabinets or external electrical connections.

Durable battery chemistry

To ensure that the battery has a long life, charge and discharge management is the key element. End-of-charge and end-of-discharge detection methods are used to prevent over-charge and over-discharge, and are programmed into the battery management system.

The choice of a nickel-based battery was the result of a two year study with French research laboratory, CEA-INES, part of the National Institute for Solar Energy. The researchers compared battery technologies which can be used in extreme conditions. "Rainfall, solar radiation and intense heat as well as sand storms and desert winds of up to 100km/h all had to be taken into account," explains Raphael Baillot, Head of R&D for Sunna. Air temperature is the most sensitive environmental factor for a battery and the objective was to find the most resistant battery chemistry for desert environments, and improve its performance and lifespan in tough conditions.

> "The nickel-based batteries allow us to reach an unrivalled lifespan for our products."

Unrivalled lifespan

Accelerated aging tests confirmed NiMH technology for its efficiency and predicted a lifespan of ten years as well as suitability for Africa or Middle East desert operating conditions. Here temperatures can range from around 58°C during the day to 10°C at night, and in some regions at certain times of the year can even fall to around freezing. The battery therefore needs to function reliably over a wide temperature range. "The nickel-based batteries allow us to reach an unrivaled lifespan for our products," says Baillot.

The high temperature resistance of this metal allows us to get an optimum performance even under the harshest environments on earth," says Sunna engineer, Nicolas Mercadal. "This is the best battery technology for solar lighting applications."

"Because the battery stores solar energy during the day for use at night, efficiency of the system's energy storage is critical. In African countries, lead acid batteries in similar systems have a life of up to two years and can expire in less than a year. "Reliability provided by NiMH batteries prevents additional maintenance costs," says Laura Pargade, Sunna's Head of Marketing. "A smart electronic energy management system optimizes the lighting program whatever the weather and enhances the battery lifespan." NiMH offers

△ *A long lasting NiMH battery which withstands temperatures from -20°C to +70°C powers highly efficient LED lights. The unit's intelligent electronics system manages energy, optimises the lighting program and enhances the durability of the battery, offering a ten year lifespan.*

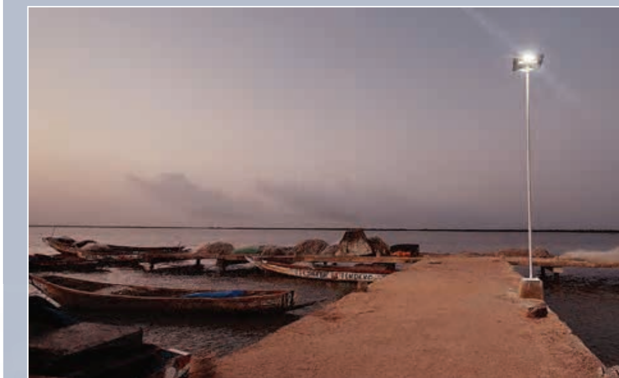
reasonable specific energy (55 to 70 Wh/kg) and covers one of the largest temperature ranges available for rechargeable battery technologies, from -20 to + 70°C.

Communities in over 20 countries are now benefiting from the systems. Many are in Africa, including Senegal, Nigeria and Cameroon, as well as a refugee camp in Jordan.

Blackouts in remote areas could be a thing of the past thanks to solar lighting systems based on NiMH battery technology with the potential to bring light to everyone, everywhere, reliably and sustainably. Ni

▽ *Sunna's newly developed Nanogrid system connects a solar streetlight to eight homes to offer indoor lighting and mobile phone charging.*

FLORIAN COAT



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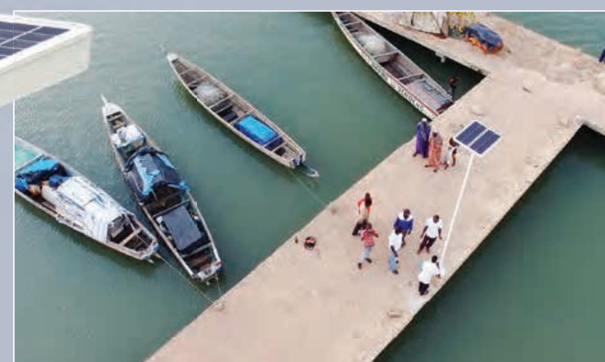


BENOIT POITEVIN

△ *Sunna's iSSL Maxi solar powered light system is lighting the harbour of Ziguinchor, Senegal.*

Extending market hours

Ziguinchor is the chief town of the Casamance area of Senegal and has a population of over 230,000. It lies at the mouth of the Casamance River and has a bustling harbour, with areas dedicated to the fishing industry where locally caught fish are smoked and sold. Before the municipality installed the Sunna Design solar street-light "Maxi" system, the fishermen attached flashlights to their heads with tape to enable them to work in the dark. Selling fish when the fishing boats arrived at the dockside was restricted because of the darkness but now, with the aid of the solar street lights, commercial activities which start there at 4 a.m. are being developed. Ni

▽ *Before the solar lighting system fishermen relied on improvised head torches.*

FLORIAN COAT

New Publication

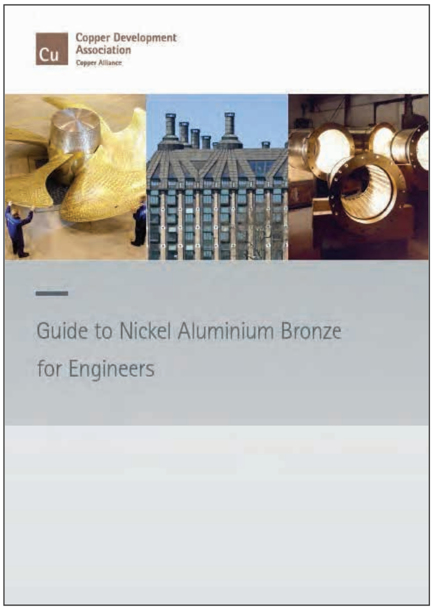
Guidance on nickel aluminium bronze for engineers

Alloys of copper and aluminium are known as aluminium bronze and their corrosion resistance and strength can be improved with the addition of nickel in combination with iron, producing nickel aluminium bronzes. These alloys also offer excellent galling properties. End uses range from aircraft landing gear bearings to sea water pumps and valves, propellers and non-sparking tools. The alloys are manufactured both in wrought and cast forms.

The most commonly used alloys have around 5% nickel. Their microstructure is complex, which allows hardening but also requires strict control during manufacture and heat treatment to obtain optimum properties for specific applications.

A newly-released publication offers practical guidance for engineers wishing to specify, design or produce nickel aluminium bronze components for marine, aerospace and other sectors. Their corrosion behaviour is explained and information given to obtain good service performance. Methods of manufacture, welding and fabrication are described and a list of references and useful publications is provided. Full details of designations, specifications and related composition and mechanical property requirements are included in an appendix.

A PDF version of CDA Publication 222 can be downloaded from www.nickelinstitute.org.



Nickel and nanotechnology

offer a solution for overheating batteries

▽ *A thin polyethylene film prevents a lithium-ion battery from overheating, then restarts the battery when it cools. The film is embedded with spiky nanoparticles of graphene-coated nickel.*

ZHENG CHEN

Stanford University researchers have developed the first lithium-ion battery that shuts down before overheating and then restarts immediately when the temperature cools.

The new technology could prevent the kind of fires that have prompted recalls and bans on a wide range of battery-powered devices, from recliners and computers to navigation systems and hoverboards.

"People have tried different strategies to solve the problem of accidental fires in lithium-ion batteries," said Zhenan Bao, a professor of chemical engineering at Stanford. "We've designed the first battery that can be shut down and revived over repeated heating and cooling cycles without compromising performance."

To address the problem Yi Cui, Bao and postdoctoral scholar Zheng Chen turned to nanotechnology.

Bunched together, nanoparticles of graphene-coated nickel conduct electricity. When the battery overheats, the particles separate and electric current stops flowing. During cooling, the particles reunite and the battery starts producing electricity again.

"Compared with previous approaches, our design provides a reliable, fast, reversible strategy that can achieve both high battery performance and improved safety," Cui said. "This strategy holds great promise for practical battery applications."

UNS details

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

UNS No.	C	Co	Cr	Cu	Fe	Mn	Mo	N	Nb	Ni	P	S	Si	Ti
S24000 p. 7	0.08 max.	-	17.0-19.0	-	bal.	11.5-14.5	-	0.20-0.40	-	2.3 -3.7	0.060 max.	0.030 max.	1.00 max.	-
S30400 p. 4, 5, 6, 7, 11	0.08 max.	-	18.0-20.0	-	bal.	2.00 max.	-	-	-	8.0-10.5	0.045 max.	0.030 max.	1.00 max.	-
S30403 p. 9	0.03 max.	-	18.0-20.0	-	bal.	2.00 max.	-	-	-	8.0-12.0	0.045 max.	0.030 max.	1.00 max.	-
S31600 p. 4	0.08 max.	-	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	-	-	10.0-14.0	0.045 max.	0.030 max.	1.00 max.	-
S31603 p. 6, 9	0.030 max.	-	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	-	-	10.0-14.0	0.045 max.	0.030 max.	1.00 max.	-
S31653 p. 4	0.030 max.	-	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	0.10-0.16	-	10.0-14.0	0.045 max.	0.030 max.	1.00 max.	-
S32205 p. 4, 6, 16	0.030 max.	-	22.0-23.0	-	bal.	2.00 max.	3.00-3.50	0.14-0.20	-	4.5-6.5	0.030 max.	0.020 max.	1.00 max.	-
S32304 p. 2, 4, 6, 7, 9, 16	0.030 max.	-	21.5-24.5	0.05-0.60	bal.	2.50 max.	0.05-0.60	0.05-0.20	-	3.0-5.5	0.040 max.	0.040 max.	1.00 max.	-

NICKEL CATALYST RESEARCH moves into high gear

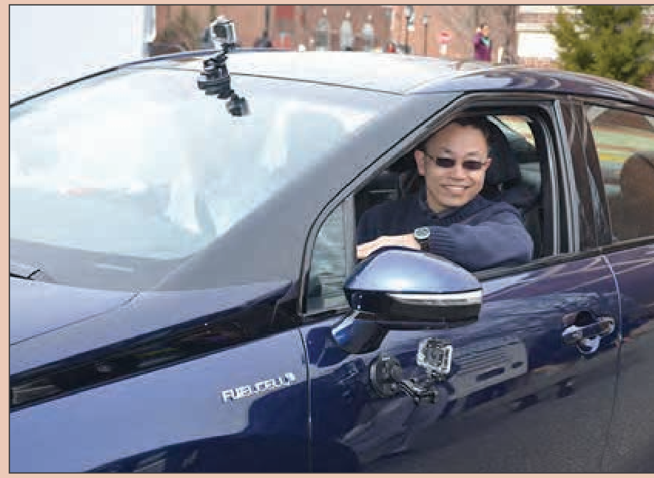
In the search for cheaper, clean, renewable energy, North American researchers are working to develop new nickel catalysts that will make fuel cells more affordable.

Transportation by passenger cars, trucks, buses, rail, marine and air accounts for 20% of energy use in the US, primarily in the form of fossil fuels, so the search is on for environmentally-friendly alternatives.

The two most promising candidates for cars are rechargeable batteries and fuel cells, which convert the chemical energy of hydrogen to electricity. Battery cars have a short driving range and long battery charging time. By contrast, fuel cell cars can be charged in less than five minutes and be driven for more than 500km/300 miles in one charge.

While rechargeable batteries, to date, have had the greatest commercial success, Dr. Yushan Yan and his colleagues from the University of Delaware recently reported a breakthrough that promises to make fuel cells more affordable by replacing expensive platinum with catalysts made from nickel at a significantly lower cost.

The commercialization of fuel cells is hindered by the high price of platinum (~$50 per gram). The current state-of-the-art fuel cell is the proton exchange membrane fuel cells (PEMFC) using platinum for both the anode and cathode. However, switching the operating environment from an acidic to a basic one (that is, a hydroxide exchange membrane fuel cell, HEMFC), opens up the possibility of using nickel catalysts and other less expensive components.



UNIVERSITY OF DELAWARE

△ *Yushan Yan, at the wheel of a fuel cell vehicle, is conducting research on the use of nickel as a catalyst in an alkaline electrolyte that promises to bring down the cost of hydrogen fuel cells.*

Peak power density of HEMFC is less than PEMFC, but Dr. Yushan and his colleagues synthesized Ni nanoparticles supported on nitrogen-doped carbon nanotubes which displays activities similar to Pt in HEMFC. "This new hydroxide exchange membrane fuel cell can offer high performance at an unprecedented low cost," Yan says. Ni

STAINLESS STEEL SELECTED FOR GAUDÍ’S BARCELONA MASTERPIECE

LA SAGRADA FAMILIA

134 years after the first stone was laid, Antoni Gaudí’s magnificent basilica, the Sagrada Familia in Barcelona is approaching the final stages of construction. Nickel-containing stainless steel is playing an important role in this extraordinary structure.

Gaudí, a committed Roman Catholic, was himself relaxed about the time taken for his massive edifice to be built saying “The work of the Sagrada Familia progresses slowly because the master of this work is in no great hurry,” referring to his ‘client,’ God.

△ *Nickel-containing duplex stainless steels are an important structural component. The Sagrada Familia’s 18 towers will reach heights from 94 to 172 meters.*

Completion is scheduled for 2026, to coincide with the centenary of the architect’s death. When completed, the 18 towers of the Sagrada Familia will reach heights from 94 to 172 meters and nickel-containing stainless steel is an important structural component. Selected because of its high strength, exceptional corrosion resistance and reduced life cycle costs, stainless steel rebar, machined components and plasma-cut plate products are being supplied by Outokumpu. Alloy 2304 (UNS S32304) and Alloy 2205 (S32205) nickel-containing duplex stainless steels have been selected as cost-efficient and long lasting solutions for the demanding structures.

Six new towers have still to be added to the structure, the highest of which will make the basilica Europe’s tallest religious building. While it’s impossible to estimate how much the construction of the Sagrada Familia has amounted to over its lifetime, the annual costs of construction and maintenance are currently around €25 million a year, funded by the three million annual visitors to the site and private donors. Ni

OUTOKUMPU — COURTESY OF SAGRADAFAMILIA