NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

NICKEL, VOL. 37, Nº 2, 2022

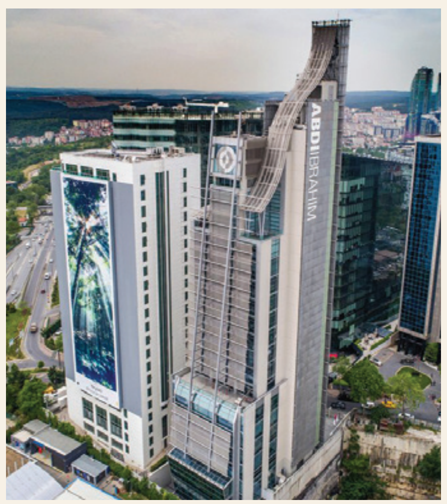
Nickel empowering sustainability

Weathering steel gives rise to solar panels

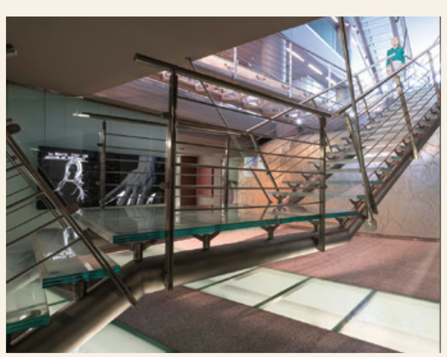
Renewable energy shines with concentrated solar power

V2G–More in store
How EVs can help to power the grid

TONI NICOLINI



The Abdi Ibrahim Tower was designed by architects Dante O. Benini & Partners, Milan



CASE STUDY 25
ABDI IBRAHIM TOWER

In Istanbul, the headquarters of the pharmaceutical company Abdi Ibrahim stands out as an important example of Italian architectural design. Nickel-containing stainless steel has been used extensively for both the external and internal parts of the 21,000 m² tower which comprises 25 floors and stands 120 metres tall.

On the exterior, Type 316 (UNS S31600) stainless steel was selected for vertical shields fabricated from micro-perforated sheets. These panels hide the air conditioning systems and also filter the natural light, contributing to the climatic comfort of the workplace. On the south facing walls of the building, curtains connected with an inclined tubular structure are also made from Type 316.

The interior of the building features a striking suspended staircase open to three levels in the main entrance hall, giving the impression that it is 'hanging in the void'. It is connected at only two points by shaped saddles that embrace the lower part of load-bearing tubular elements. These 210.3 mm diameter tubes, the 12 mm diameter transverse rods of the parapet as well as the 40 mm welded tube handrails are also fabricated from Type 316, with a satin finish. Stainless steel details, such as fencing, access gates, graphic applications and interior decorative elements complete the building.

Source: *Centro Inox/ Inossidabile 225 http://www.centroinox.it/* Ni

EDITORIAL:
NICKEL EMPOWERING SUSTAINABILITY

Nickel has an essential role to play in delivering the low carbon, renewable energy that we desperately need to help combat climate change. The International Energy Agency's roadmap to achieve net zero emissions by 2050 identifies the contributions of various renewable technologies to electrical capacity. Nickel's properties in stainless steels, batteries, nickel alloys and low alloy steels deliver in almost every renewable technology.

SOURCE: NET ZERO BY 2050: A ROADMAP FOR THE GLOBAL ENERGY SECTOR -INTERNATIONAL ENERGY AGENCY

	Electrical capacity(GW)					Shares (%)			CAAGR(%)	
	2019	2020	2030	2040	2050	2020	2030	2050	2020-2030	2020-2050
Total capacity	**7,484**	**7,795**	**14,933**	**26,384**	**33,415**	**100**	**100**	**100**	**6.7**	**5.0**
Renewables	**2,707**	**2,994**	**10,293**	**20,732**	**26,568**	**38**	**69**	**80**	**13**	**7.5**
Solar PV	603	737	4,956	10,980	14,458	9	33	43	21	10
Wind	623	737	3,101	6,525	8,265	9	21	25	15	8.4
Hydro	1,306	1,327	1,804	2,282	2,599	17	12	8	3.1	2.3
Bioenergy	153	171	297	534	640	2	2	2	5.7	4.5
of which BECCS			28	125	152		0	0	n.a.	n.a.
CSP	6	6	73	281	426	0	0	1	28	15
Geothermal	15	15	52	98	126	0	0	0	13	7.4
Marine	1	1	11	32	55	0	0	0	34	16

In this edition we look at nickel in solar energy specifically – both photovoltaic and concentrated solar power. These technologies are set to represent a significant source of renewables by 2050 according to the roadmap.

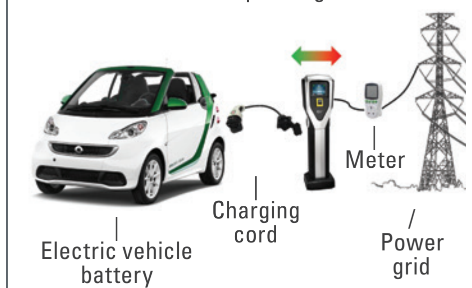
The combination of renewable energy and electrical vehicles is compelling. The US EPA estimates that transportation accounted for the largest portion of US GHG emissions in 2020. To increase the appeal of EVs, much work is happening to develop energy intensive and long lasting batteries. We report on developments taking place in Canada with the promise of the 4-million mile battery.

The Nickel Institute is all about making sure that nickel-containing materials are used properly. If you wondered about the differences between stainless steel types then look no further than our article on page 12 with tips on what to consider when looking for alternative and possibly less expensive materials. Knowledge of the qualities of the various families of stainless steel can help avoid costly mistakes, and ensure that materials specified are sustainable. If in doubt, contact the Nickel Institute's technical inquiry service. We're here to help.

Clare Richardson
Editor, *Nickel*

SIMPLIFIED VEHICLE-TO-GRID (V2G) SCHEMATIC

Bi-directional flow of energy between the EVs and power grid



REF: BIBAK, B., & TEKINER-MOĞULKOÇ, H. (2021)

The 4-million mile battery opens up the possibility of using parked EVs to help power the grid. Read "There's more in store with 4-million mile batteries" on page 11.

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Nickel magazine is published by Nickel Institute

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Design: Constructive Communications

ISSN 0829-8351

Printed in Canada on recycled paper by Hayes Print Group

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NICKEL NOTABLES

Thirsty leaves?

AMERICAN CHEMICAL SOCIETY

How do you know your crops are in need of water before it's too late? Researchers in Brazil have created a wearable sensor for plant leaves made of nickel deposited in a narrow, squiggly pattern that can detect water loss earlier. In *ACS Applied Materials & Interfaces*, the team reports they attached the metal electrodes to a living plant in a greenhouse. The device wirelessly shared data to a smartphone app and website, and a simple, fast machine learning technique successfully converted these data to the percent of water content lost. Proven reliable indoors, the devices will now be tested outdoors to determine when plants need to be watered, potentially saving resources, and increasing yields.

Extra extract!

A new bioleaching technology to extract minerals like nickel and cobalt from mine tailings is making headlines. BacTech Environmental Corp., based in Toronto, Canada, has set up a pilot plant in northern Ontario where 75-100 million tonnes of tailings sit in the Greater Sudbury Area. The tailings rock, normally waste product, will be put in large stainless steel tanks where bacteria separates the valuable metals from the rock over six days, "literally attacking it", says BacTech CEO Ross Orr. High demand for electric vehicle batteries, has increased the value of minerals like nickel and cobalt, and made this process more viable; and with each tank working independently it can easily be scaled up.

ROSS ORR

Fuel cell advance

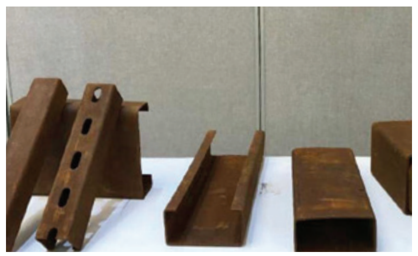
Carbon-coated nickel is proving to be the answer to creating a completely precious-metal-free hydrogen fuel cell. A team of researchers from the University of Wisconsin-Madison, Cornell University, and Wuhan University have designed a nickel-based electrocatalyst with a 2-nanometre shell made of nitrogen-doped carbon. This ground-breaking advance with a Ni@CNx anode, paired with a Co–Mn spinel cathode, exhibited a record peak power density of over 200 mW/cm^2. Ni@CNx exhibited superior durability when compared to a nickel nanoparticle catalyst due to the enhanced oxidation resistance provided by the CNx layer. According to the team, "the fuel cells do not need a special unit to remove carbon monoxide and can use less refined hydrogen, further reducing costs."

Tiny name tag

WADA PRECISION DENTAL RESEARCH INSTITUTE

A manufacturer of dentures in Japan, Wada Seimitsu Dental Laboratory, has started a service to attach the owner's 'name tag' to dentures to help identify the person in the event of a disaster. Engraved on a tiny nickel-chromium alloy plate affixed to the inside of the insert, is the family name and a two-dimensional code connected to the dental clinic that provided the denture. A resin coating is applied on top for added comfort. It's a simple idea that evolved from the Great East Japan Earthquake of 2011. The data can be read with a smartphone or other device and refers the 14-digit number displayed to Wada Precision. If the idea takes off, the goal is to open it up to competing denture manufacturers, with the intention of developing it into a nationwide social infrastructure.

WEATHERING STEEL'S MOMENT IN THE SUN



Weathering steel components for solar photovoltaic racking systems

Solar farms are blooming in fields across the globe and producing a new crop: solar energy. Photovoltaic (PV) systems made up of solar panels, are fast becoming the most recognisable of renewable energy technologies. A typical PV panel is composed of a layer of solar grade crystalline silicon, protected by a layer of glass and held together by an alloy frame. While nickel does not play a direct role in harnessing solar energy from PV systems, its presence can be important to their functioning in a more indirect manner – the supporting structures that aim the solar panels at the sun to optimise sunlight capture.

The key attributes for solar panel bracket materials are strength, toughness, and corrosion resistance. They must be durable to achieve the designed life of the solar panel, around 30 years, with minimal maintenance cost and no environmental issues.

Traditionally PV mounting brackets have been made of aluminium, hot-dip galvanised steel and occasionally stainless steel, but recently in China weathering steel – often referred to as COR-TEN® steel – is increasingly being selected.

Materials – the pros and cons

In China, approximately 50% of PV mounting structures are made of hot-dip galvanised zinc steel and 40% from aluminium. A smaller amount is made from stainless steel or glass reinforced plastic. Compared to hot-dip galvanised steel, the tensile strength of aluminium is relatively low and while its corrosion resistance is good, the cost is high. Aluminium also requires surface treatment to enhance its corrosion resistance. It is normally used in residential PV panels where the wind load is low and little maintenance is expected.

Galvanised steels possess higher strength and are usually used in heavy wind load areas. Hot-dip galvanising is required to improve corrosion resistance, but it requires regular maintenance, and has environmental concerns.

Stainless steel is also suitable for PV mounting structures with superior strength and corrosion resistance to the other solutions, however, it costs more and hence is not as widely adopted.

Recently, weathering steel has been used in several high profile PV applications in China and looks promising elsewhere. It is a high strength steel alloyed with small additions of Cr, Cu and Ni, that develops a surface oxide layer resistant to spalling (metal loss by flaking of rust). It exhibits better atmospheric corrosion resistance compared to common carbon steels and does not require a protective coating, such as paint or galvanising. Weathering steel has the advantage of being lower cost and is maintenance free compared to aluminium and galvanised steel. A new China PV bracket standard, NB/T 10642-2021, stipulates weathering steel as one of the recommended materials for PV brackets. Even though the amount of nickel in weathering steel is small (around 0.1–0.65%), the total tonnage of nickel can be quite large considering the number of solar panels that will be erected in the coming decades. This relatively small amount of nickel is essential to achieve enhanced corrosion resistance of weathering steel for PV mounting structure applications.

Throughout the value chain there is growing awareness of the benefits of weathering steel, with increased marketing efforts being made by steel mills, design institutes and engineering companies.

According to China's 14th five-year plan for clean energy strategies to achieve carbon neutrality and carbon peak goals, new materials and innovative applications are encouraged. Weathering steels in PV mounting structures are proving to be one such effective technology. And as the carbon footprint for building and construction is a top priority area for China, weathering steel and nickel will have a role to play. Ni

Mounting structures consist of piles for ground mounting, legs, column, beams, rail and clamps, and other assembly fixtures.

CONCENTRATED SOLAR POWER
RENEWABLE ENERGY

US OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY

The parabolic trough system employs reflectors that focus solar radiation onto a fluid-filled receiver tube, concentrating it by a factor of about 100.

Reducing energy-related CO_2 emissions is pivotal to limiting climate change, with the main drivers to bring about the required carbon reductions being renewable energy and energy efficiency. Concentrated solar power (CSP) is one such renewable energy technology set to increase dramatically in the foreseeable future. It will need to provide energy at a competitive cost to outshine the competition.

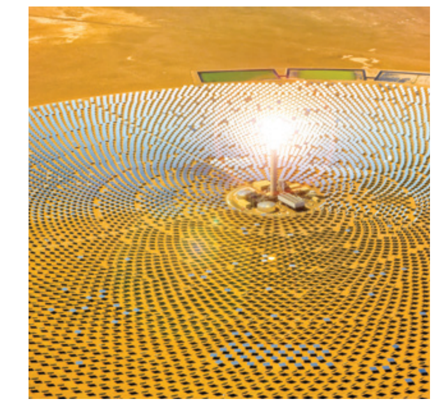
Concentrated solar power (CSP) uses mirrors to reflect, concentrate and focus sunlight onto a receiver, which collects and transfers solar energy to a heat transfer fluid. This can be used to supply heat to end-use applications or to generate electricity through conventional steam turbines. CSP technology coupled with thermal energy storage (TES) enables the technology to deliver continuously on days when there is no sun, or before sunrise and after sunset. Early CSP systems without TES are referred to as Generation 1, whereas currently installed CSP systems with TES are called Generation 2 systems.

Nickel in generations of concentrated solar power
Operating temperatures sufficiently high for CSP plants to generate electricity can only be maintained in areas of the world with high, direct solar radiation. There are currently two distinct CSP technologies, parabolic trough or central tower. Nickel-containing stainless steels and nickel-based alloys play a key role in these techniques because they withstand high temperatures and the corrosivity of molten salts, resist wind and erosion in harsh desert climates and are easy to work with.

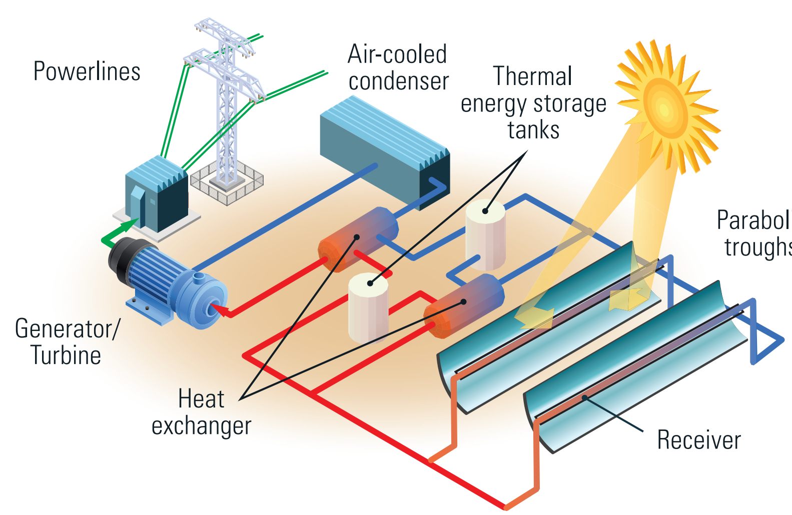
The parabolic trough system employs reflectors that focus solar radiation onto a fluid-filled receiver tube, concentrating it by a factor of about 100. The thermal energy thus recovered is used to generate steam, which spins a turbine to power a generator. Synthetic oil or molten salt can be used as a heat transmission fluid. In heat exchangers, water is converted to steam that drives conventional turbines. Parabolic troughs attain operating temperatures of 393 °C to 550 °C (739 °F to 1,022 °F) depending on the nature of the heat transfer fluid. The receiver tubes are made of heat-resistant nickel-containing stainless steel which are coated with a selective layer and sealed in a vacuum insulated borosilicate glass tube. One advantage of nickel-containing stainless steel is the ease with which a finely polished finish can be applied, which guarantees that the coating stays in place. Also, stainless steel is suited to cope with both temperature differences in the desert which can cause condensation leading to a corrosion risk, as well as the high operating temperature.

Central tower technology incorporates a heliostat as a central receiver. Heliostats, which are computer-controlled mirrors, track the sun along two axes and focus solar energy on a central receiver at the top of a tower. There, a fluid is heated, which serves to produce steam and drive generators. Receiver tubes have to face a multitude of requirements: mechanical resistance, cycles of hot service and cold idling (night time) as well as 25 to 35 years anticipated service life. Currently, only nickel alloys are capable of meeting these conditions. Nickel-base Alloy 625 (UNS N06625), about 61% nickel, is typically used as a standard grade in this application and Alloy 800HT (N08811), 30–34% nickel, or Alloy 230 (N06230), 47–65% nickel, are considered as alternatives.

Working principle of a central tower receiver solar power plant
In this technology, molten salt can be used as the heat transfer fluid. Salt retains more energy than substances that are liquid at ambient temperature. Molten salt makes it easier and more efficient to incorporate storage facilities allowing for 24 hour power generation. The vertical set-up of a central tower system also handles molten salt more easily than the mostly horizontal layout of a trough system. Currently deployed central tower systems feature both a hot

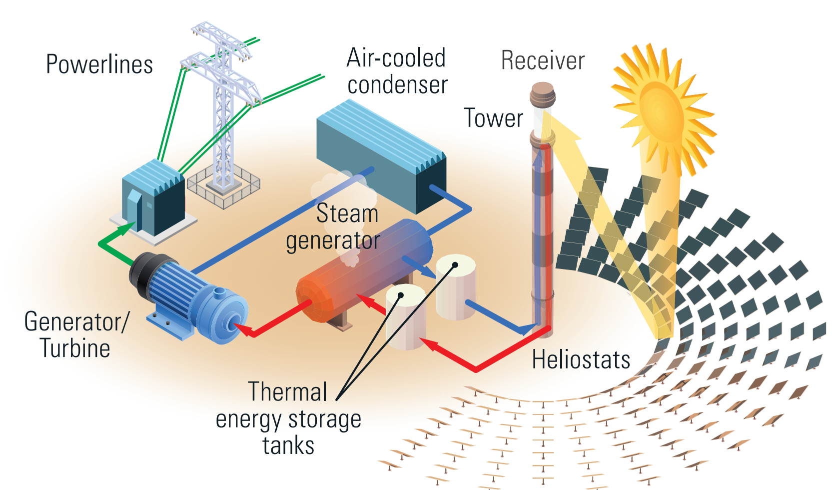


Concentrated solar power (CSP) uses mirrors to reflect, concentrate and focus sunlight onto a receiver, which collects and transfers solar energy to a heat transfer fluid.



NREL/SAM

Conventional parabolic trough plant using synthetic oil



NREL/SAM

Central tower technology can reach higher temperatures between 500 °C and 1,000 °C (932 °F and 1,832 °F) and achieve higher efficiencies than trough systems.

DUBAI ENERGY AND WATER AUTHORITY (DEWA)

The Noor 1 extension of the Mohammed bin Rashid Al Maktoum Solar Park in the United Arab Emirates has used around 800 kg Ni/MW in receiver tubes of the trough part and over 1,300 kg Ni/MW in the central tower receiver and molten salt tanks.

(565 °C) and a cold (290 °C) molten salt storage unit. For resistance against high temperatures and corrosion, the former is made of nickel-containing stainless steel, while the latter is made of carbon steel.

Towards Generation 3

By 2030, the Levelised Cost of Electricity (LCOE) value of CSP plants in G20 countries is likely to decline by 35% to 8.6 US cents per kilowatt-hour (kWh) from an estimated 13.2 cents/kWh in 2018. The shift from the first to second generation of CSP enabled the LCOE to decrease from 21 to 9 cents/kWh while the use of nickel increased. 5 US cents/kWh represents the cost point where solar energy production becomes competitive with traditional energy sources as defined by the US Department of Energy.

Analysis of the CSP subsystems' capital costs, energy efficiencies, and bounds of integration indicates the first two generations of CSP technology are unlikely to achieve the 5 cents/kWh LCOE target. Currently in the R&D stage, Generation 3 systems are chasing this goal. Key is power cycle efficiency which can be maximised by raising its temperature. Research into Generation 3 CSP systems suggests – among other options – saturated CO_2 to feed the power cycle. Consequently, the heat transfer media, TES, and the receiver's maximum temperature must be similarly increased to develop a system concept capable of achieving cost efficiencies. As temperatures and stresses increase to achieve such increased efficiency, it's unlikely that that is going to happen without the unrivalled properties of nickel alloys. It seems that no increase in efficiency can happen without higher alloyed materials. Also, the extent to which LCOE of high carbon footprint energy sources will be burdened by CO_2 taxes (which CSP doesn't have to bear) will likely offer breathing space for this form of energy. Also, it will take a couple of years before performance of these experimental Generation 3 systems can truly be evaluated. All this makes it very likely that nickel will continue to shine for years to come and so continue to play its valuable role in limiting climate change. Ni

"Recent investments in CSP capacity are however insufficient to reach projected capacity goals by 2050. Efforts are needed to support R&D, recognise CSP's Generation 2 storage and flexibility capabilities, reduce its costs and increase the scale of the industry." IEA tracking report on CSP – November 2021

THERE'S MORE IN STORE WITH 4-MILLION MILE BATTERIES

HOW EVS CAN HELP POWER THE GRID

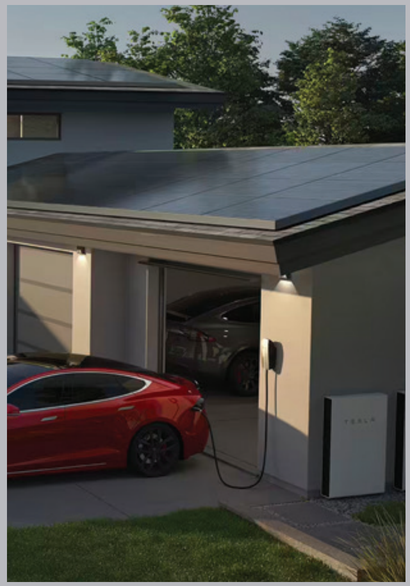
Significant advances in extremely long-life lithium-ion batteries means big news for vehicle-to-grid applications (V2G), whereby smart charging technology enables energy to be pushed back to the power grid from the battery of an electric vehicle. This bi-directional flow will allow solar and wind energy to be stored in the batteries of electric vehicles and released to the grid on demand.

The team of researchers at Canada's Dalhousie University, led by Professor Jeff Dahn, a world-renowned battery scientist and NSERC/Tesla Canada Chair, have now developed and demonstrated batteries with an ultra-long lifetime that last four million miles (almost six million km). The term "Million Mile" battery emerged after Dahn's 2019 open access publication in the *Journal of the Electrochemical Society* (JES), which concluded, "Cells of this type should be able to power an electric vehicle for over 1.6 million kilometres (1 million miles) and last at least two decades in grid storage".

This was achieved with single crystal $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532)/graphite cells that started testing in October 2017 and are still running at room temperature, realising 4.5 years of continuous cycling with only ~ 5% degradation at 1C:1C. Dahn and team also demonstrated the impact of upper cut-off voltage (UCV) in their 2022 JES publication concluding; "NMC811/graphite cells will benefit from an enormous lifetime boost when operated at a limited UCV of 4.06 V, where decades-long lifetimes can be achieved at 20–30 °C, if the best graphites are selected". They reported that NMC532 cells balanced and charged to 3.8V exhibit "better coulombic efficiency, less capacity fade and higher energy density compared to LFP cells and are projected to yield lifetimes approaching a century at 25 °C."

"While 800 [cycles] (100% depth of discharge) is enough for an electric vehicle battery, in vehicle-to-grid operation, vehicles will be charged and discharged when parked, so more than 10,000 cycles will be required," Dahn said.

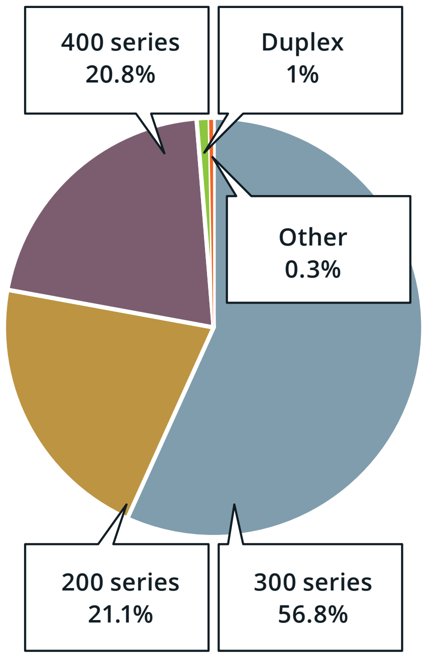
Looking at the bigger picture, the long-term goal inevitably is not to make an electric car drive millions of miles but to be able to use the battery in V2G applications, utilising storage capacity for solar and wind energy in electric vehicle batteries that are stationary most of the day. Ni



TESLA

The idea of 'vehicle-to-grid' or V2G is to use the batteries in parked electric cars to take in and store excess electricity, providing an electricity reserve to power the grid. With renewable energy, management of the grid becomes more complex because availability of energy depends on the sun shining or the wind blowing. V2G is one solution that can make the most of renewable energy and better manage fluctuations. It will rely on technological breakthroughs like 'smart charging' and the 'million mile' battery to make it possible.

NICKEL ALLOY SELECTION
KEEPING IT IN THE FAMILY



FIGURES COURTESY OF WORLD STAINLESS

Percentage production of stainless steel by family (2021)

How can I make a product better or can I make the same quality product less expensively? Everyone, from design engineers to manufacturing managers to buyers, asks this question. These are important considerations to enable a company to stay one step ahead of the competition. And when the product involves stainless steel, specifiers may think of considering a different alloy, perhaps one that is lower cost. Often that involves looking at an alloy from a different stainless family.

So, what needs to be considered when looking at a change in alloy family for a specific application?

Duplex family

The duplex (austenitic-ferritic) family has much higher yield and tensile strength than either austenitics or ferritics, so it is of great interest when the strength can be used to reduce wall thickness of a tank or pressure vessel. The ductility is lower, though generally still reasonably high. But if formability is important the higher strength can be a disadvantage. Welding can also be a challenge, not because it is difficult, but it differs from austenitic alloys that welders are much more familiar with. There are even significant differences between welding the different sub-families, e.g. lean duplex, standard duplex and superduplex which need to be taken into account. Also, the temperature of the intended application is important as duplex alloys have some limitations. The ferrite phase becomes brittle at cryogenic temperatures and detrimental microstructural changes can occur at elevated temperatures as low as 270 °C. A further challenge is that there are many different alloys in each sub-family, which creates difficulties when sourcing a complete package of different sizes and product forms. Ever since the advent of modern, nitrogen alloyed duplex grades, their market share was expected to increase significantly, but over the last ten years it has hovered around just 1% due to complexity of usage.

200 series

The 200 series stainless steels, which are fully austentic, have been in existence for over 70 years now. They contain a higher amount of manganese so that the nickel content can be reduced, but not totally eliminated. Most of the 200 series production today has been in the lower chromium alloys, typically 16% down to 12%. This compares to the 17.5% minimum chromium of 304 type alloys, which gives higher corrosion resistance. Where only a minimum of corrosion resistance is needed, 200 series may find usage. 200 series alloys work harden quickly during cold forming, which sometimes results in cold cracking long afterwards. Copper is often added to these alloys to lower the work hardening rate. Care must therefore be taken when selecting low chromium 200 series alloys to ensure they have adequate corrosion resistance and suitable fabrication properties.

Ferritic stainless steels

Ferritic stainless steels have been available since their unique properties were discovered over 110 years ago. The chromium content of this family ranges from the absolute minimum by definition of 10.5% to nearly 30%. It is most often used in sheet thicknesses (≤ 4 mm), as extreme grain growth can be a problem in plate thicknesses and especially during welding. As with duplexes, the ferrite phase has limitations both at low and high temperatures. What initially attracts many specifiers to the ferritic family is the promise of low cost, as they contain no or very low nickel. However, production costs are typically higher than for austenitic alloys, and limitations in thickness, use at various temperatures and weldability has restricted their growth. In fact, since 2010 the ferritic stainless steel family has decreased in percentage of total production by about 30%. As with any possible change of material, it is important to understand how each property affects both fabrication and end use. However, there are many suitable applications, such as thin-walled heat exchanger tubes where the lower rate of thermal expansion and slightly higher thermal conductivity of ferritics can be of value.

Should you be thinking of changing to another stainless steel alloy, whether within a stainless family or to a different family, the Nickel Institute can offer guidance for your specific application through our online Technical Service.
www.inquiries.nickelinstitute.org NI

PLYMOUTH TUBE CO.

A tube bundle in Sea-cure® superferritic stainless steel (UNS S44660), used to cool the crude oil coming from storage in salt domes at the US Strategic Petroleum Reserve.

JOHNSEN ULTRAVAC (JUV).

Welded equipment such as this vacuum chamber involving different product forms, a wide variety of metal thicknesses, and a highly polished surface finish is most easily produced using 300 series austenitic stainless steels.

Geir Moe P.Eng. is the Technical Inquiry Service Coordinator at the Nickel Institute. Along with other material specialists situated around the world, Geir helps end-users and specifiers of nickel-containing materials seeking technical support. The team is on hand to provide technical advice free of charge on a wide range of applications such as stainless steel, nickel alloys and nickel plating to enable nickel to be used with confidence.
https://inquiries.nickelinstitute.org/

Q: I have heard about the Pitting Resistance Equivalent Number (PREN) for stainless steel. How do I use it for material selection?

PREN is a formula to rank the resistance to initiation of pitting of various stainless steels based on their composition. There are many formulas which have been derived for the various stainless steel families by correlating composition with actual pitting corrosion tests. The following formula is probably the most well-known one for nickel-containing stainless steels.

PREN=%Cr + 3.3%Mo + 16%N

This formula, by itself, cannot be used for material selection for a specific environment. But the PREN can be used to identify more pitting-resistant stainless steel alloys if one has failed in service.

All stainless steels have specified minimum and maximum contents for Cr, Mo, and N and thus their actual PREN will be dependent on their actual composition. For example, the minimum and maximum Cr, Mo, and N content for various nickel-containing stainless steel in accordance with ASTM A240 are shown along with their calculated minimum and maximum PREN.

It should be emphasised that although PREN is often used to compare alloys, it is based on composition alone, and other factors that influence pitting are not considered. Such factors include inhomogeneity or segregation with the micro-structure, surface roughness or the amount of inclusions present.

In-service experience has shown that stainless steel with a PREN ≥ 40 is considered resistant to seawater. Thus, PREN can be used as a quality assurance tool to ensure that actual material is produced with a PREN exceeding 40. In fact, in ASTM A240 nickel-containing superduplex Type 2507 has a minimum PREN requirement of 41.

A more in-depth discussion of PREN is available in our publication *Guidelines for the use of stainless steel and nickel-containing alloys in water* (11003). Ni

	%Cr	%Mo	%N	%Ni	PREN (min – max)
Type 304L	17.5–19.5	–	–	8.0–12.0	17.5–19.5
Type 316L	16.0–18.0	2.00–3.00	–	10.0–14.0	22.6–27.9
Type 2205	22.0–23.0	3.0–3.5	0.14–0.20	4.5–6.5	34.1–37.8
Type 2507	24.0–26.0	3.0–5.0	0.24–0.32	6.0–8.0	37.3–47.6
S31254	19.5–20.5	6.0–6.5	0.18–0.25	17.5–18.5	42.2–46.0

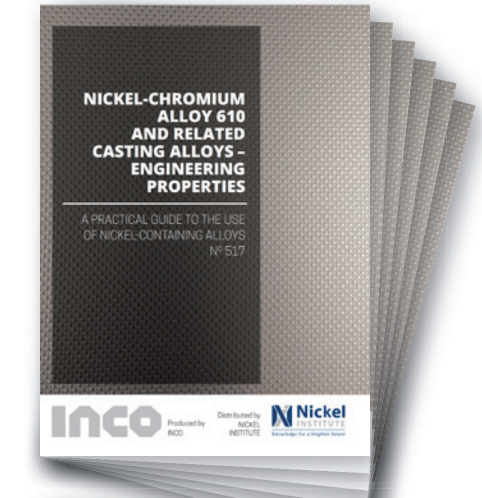
NEW PUBLICATIONS

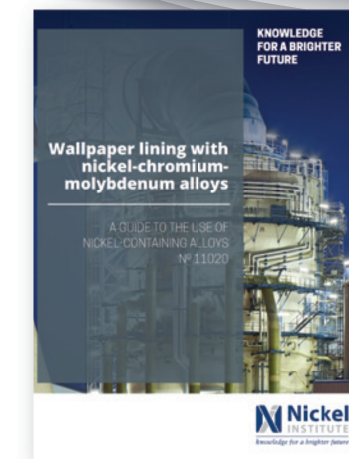
Refreshed INCO publications
Twenty-two significant technical publications, originally produced by INCO and maintained by the Nickel Institute have been refreshed and re-published. The digital quality of the guides has been improved and all publications are searchable. The original publications were written by experts in their field and the information they provide is still very relevant today. This high-quality technical information will give practitioners confidence in working with nickel-containing materials and to harness their benefits in a wide range of applications. This information is of value to materials specifiers, welders, fabricators, and engineers.

Wallpaper lining with nickel-chromium-molybdenum alloys
(11020) is the newly updated second edition of this informative publication for designers of flue gas desulphurisation units in the power industry and other chemical process equipment. This publication discusses design considerations and planning, preparation for welding, welding procedures and post-weld cleaning.

How to determine GHG emissions
The Nickel Institute has published guidance for nickel producers to help them calculate their greenhouse gas emissions. This guidance considers the complexity of nickel production and will contribute to scientifically robust and reliable data that is comparable throughout the entire industry. The guidance specifies the principles, requirements and methodologies for quantifying and communicating GHG emissions from refined nickel metal production processes and the associated cradle-to-gate carbon footprints of their products and precursors, such as nickel ores from mining, nickel concentrates from beneficiation and ore preparation, as well as nickel intermediates from primary extraction from both lateritic and sulfidic nickel metal production. The application of this guidance allows nickel producers as well as their customers and other stakeholders to calculate the climate change impact of Class 1 nickel metal production.

All publications are available for free download from the Nickel Institute website.
www.nickelinstitute.org Ni





UNS DETAILS

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

UNS	Al	B	C	Co	Cr	Cu	Fe	Mn	Mo	N	Nb	Ni	P	S	Si	Ti	W	Other
N06230 pg 9	0.20-0.50	0.015 max	0.05 0.15	5.0 max	20.0 24.0	-	3.0 max	0.30 1.00	1.0 3.0	-	-	bal	0.03 max	0.015 max	0.25 0.75	-	13.0 15.0	-
N06625 pg 9	0.40 max	-	0.10 max	-	20.0-23.0	-	5.0 max	0.50 max	8.0-10.0	-	3.15 4.15	bal	0.015 max	0.015 max	0.50 max	0.040 max	-	-
N08811 pg 9	0.15 0.60	-	0.06-0.10	-	19.0-23.0	0.75 max	39.5 min	1.5 max	-	-	-	30.0 35.0	0.045 max	0.015 max	1.0 max	0.15-0.60		Al+Ti 0.85-1.20
S31600 pg 2	-	-	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	-	-	-
S39209 pg 16	-	-	0.03 max	-	21.5-23.5	-	bal	0.5-2.0	2.5-3.5	0.08 0.20	-	7.0-9.0	0.03 max	0.03 max	0.90 max	-	-	-
S44660 pg 13	-	-	0.030 max	-	25.0-28.0	-	bal	1.00 max	3.00-4.00	0.040 max	-	1.00-3.50	0.040 max	0.030 max	1.00 max	-	-	Nb+Ti

OREGON DRAGON BENCH

JORIS LAARMAN

Using MX3D's innovative robotic 3D printer, designer Joris Laarman was able to create complex, interlocking shapes, making it look like it is forming a kind of loop. The stainless steel bench measures 10m x 3m x 2.5m.

MX3D, the creator of the world's first metallic bridge utilising 3D printing installed in Amsterdam, has unveiled its latest construction project: a 3D printed metal bench that pushes the boundaries of innovation. Named Oregon Dragon Bench, this sculptural piece was installed in front of the LeBron James Building in Beaverton, Oregon, the innovation centre of the Nike World Headquarters.

Printed in Type 2209 (UNS S39209) duplex, a nickel-containing stainless steel used for metallic 3D printing, Dutch designer Joris Laarman integrated a structural gradient, providing stability while optimising the total weight of the bench. He used topological optimisation to identify points that were exposed to the most weight and then placed the material only where it was absolutely necessary.

To make the impressive Dragon Bench, Laarman developed his own 3D-printing robot (the MX3D), which draws molten metal lines in the air to create a form. The specially adapted robotic arm melds and welds the metal (which can be stainless steel, aluminium, copper, or bronze) regardless of orientation and without the need for support structures. MX3D's robotic printing approach permits greater flexibility in shapes and textures, while using less material.

The Oregon Dragon Bench represents Laarman's continued explorations in fabrication through innovation in 3D printing. Ni