NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

NICKEL, VOL. 39, Nº 3, 2024

Strategic nickel

Nickel laterites
High Pressure Leaching

Strategic and critical
raw materials

Powering the future
Advances in nickel-based batteries

CASE STUDY 32
HAMPTON ROADS BRIDGE-TUNNEL


VIRGINIA DEPARTMENT OF TRANSPORTATION

For longevity and low maintenance, 18,000 tons (16,329 metric tonnes) of stainless steel rebar made in Duplex Alloy 2304 (UNS S32304), were specified to reinforce the concrete in critical parts. Alloy 2304 is a cost-effective material that combines excellent strength, ductility and good resistance to harsh marine environments. The Hampton Roads Bridge-Tunnel will use well over 700 tons (635 metric tonnes) of nickel.

It's the largest transportation infrastructure project in Virginia, USA's history. The Hampton Roads Bridge-Tunnel (HRBT) facility is currently undergoing a $3.9 billion USD expansion, and nickel-containing stainless steel plays a critical role both underwater and above ground in this complex and transformative endeavour. Comprised of bridges, trestles, man-made islands and tunnels, the HRBT is 3.5 miles (5.6 km) long.

The HBRT was a marvel in 1957 when the first tunnel was installed using an immersed tube method.

The expansion undertaking includes new twin tunnels and adding four more lanes, for a total of eight, to increase capacity and ease congestion. High-durability materials such as stainless steel were chosen to facilitate a 100-year design life.

The design-build is a joint venture partnering Dragados USA, Flatiron Constructors, Vinci Construction and Dodin Camperon Bernard, with HDR and Mott MacDonald as the lead designers.

Planning for the project started in 2014 and included roadway widening, 27 bridge replacements and widenings, geotechnical considerations, and environmental compliance.

In 2023, the Tunnel Boring Machine (TBM) began drilling the new 46 ft (14 m) diameter tubes approximately 50 ft (15.2 m) deeper than the existing 7500 ft (2.3 km) long immersed tube steel tunnels. The 4,700 ton (4,264 metric tonnes) TBM known as "Mary" finished boring the first tunnel this year, marking a major milestone. Ni

EDITORIAL:
THE STRATEGIC METAL OF THE FUTURE

The world is striving for decarbonisation in response to climate change and nickel has emerged as a linchpin in the transition to a sustainable economy. As nations slowly pivot away from fossil fuels, nickel, a component with a role to play in pretty much every renewable energy type, is being seen by governments as critical for their energy and economic strategies. This recognition is not merely a blip, it is a reflection of broader geopolitical and economic shifts that position nickel as a strategic asset for the 21st century. Nations need nickel. This edition of Nickel *features an analysis of where nickel stands in the strategic and critical raw materials debate.*

HARITA NICKEL (NCKL)

Harita Nickel's (NCKL) High Pressure Acid Leach (HPAL) refinery

A new generation of HPAL plants using lateritic ores is providing the nickel critical not only for the rapid electrification of the transport system, but also to meet increasing demand for stainless steel for renewable energy production (page 6).

stra·te·gic (*strə-'tē-jik):* adj.
part of a plan that is meant to achieve a particular purpose or to gain an advantage

What can be more strategic than efficient transport systems that reduce congestion and get people and goods efficiently from A to B? Or in the bid to reduce emissions, encouraging the switch to efficient EVs? Nickel plays a strategic role here too. The expansion of a key arterial road in the USA – the Hampton Roads Bridge-Tunnel – will employ well over 700 tons (635 metric tonnes) of it in the stainless steel rebar that will ensure it is operational for decades to come. And nickel is critical in the batteries that will power those electric vehicles of the future. Check out recent developments on page 10.

So, as industries, governments, and nations continue to strategise for a sustainable future, one thing is certain: nickel is a critical strategic resource – one that is shining brighter than ever. Like the stars of our back cover – the magnificent elephants of Suvarnabhumi Airport.

Clare Richardson
Editor, *Nickel*

CONTENTS

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

Stock image credits:
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NICKEL NOTABLES

Faster drug development

Researchers at The Ohio State University have developed a new nickel complex that will enable the pharmaceutical industry to create effective drugs more quickly. By simplifying alkyl bond formation, this new tool will facilitate organic chemical processes that were not possible before. According to Christo Sevov, the study's lead investigator, "By combining organic synthesis, metal chemistry and battery science in a way that no one else had, we were able to unlock their amazing properties." Making a new molecule from a single chemical reaction will make it possible for researchers to create up to 96 new drug versions in the time it would typically take to make just one. Ultimately, this will reduce development costs and time to market for life-saving medicines while increasing drug efficacy and lowering the risk of side effects. The study was published in *Nature Magazine*.

Added orthopædic strength

Researchers at Jilin University, Changchun, China, have developed a novel SLM-NiTi alloy with better tensile strength. The result? The promise of more individualised customised orthopædic implants with less need for timely and costly revisions. Nickel-titanium (NiTi) alloys are widely used by the medical industry for their unique properties. The team of Hao et al. prepared the novel NiTi alloy by using selective laser melting (SLM) technology. They discovered that "by changing the laser scanning length and scanning direction, the generation of unidirectional columnar crystals in the material was eliminated, thereby improving the tensile strain of the SLM-NiTi up to 15.6%." It's one more step forward for doctors and patients alike.

Eco-friendlier cement

In collaboration with Makassar State University (UNM) in Indonesia, Suvo Strategic Minerals has successfully transformed nickel slag into a high-strength, low-cost and low-carbon cement. Taking steps to decarbonise cement is an important endeavour as the industry is one of the world's largest GHG emitters, with demand continuing to grow. Working with nickel slag producer PT Huadi Bantaeng Industrial Park, Suvo's subsidiary, Climate Tech Cement Pty's aim was to produce an eco-friendly geopolymer cement as an alternative to traditional clinker-based cement. SSM Executive Chair Aaron Banks explains, "Achieving up to 37.5MPa (5.4 ksi) after only seven days is an outstanding first-round trial result." He added that "reducing emissions in the cement industry is analogous to the role of EVs in replacing internal combustion (engine)."

Next level single crystal superalloys

When the US Department of Energy wanted to improve casting yields for single crystal superalloys used in industrial gas turbines (IGT), Illinois-based QuesTek Innovations took on the challenge. Due to their excellent creep resistance, nickel-based superalloys are used in hot gas path components in gas turbines. To achieve their maximum mechanical capability, these materials must be cast as single crystals. The industry typically utilised conventionally cast or directionally solidified blades. A leader in Integrated Computational Materials Engineering technologies, Questek successfully developed a novel, castable single-crystal nickel superalloy containing 1% rhenium (a lower percentage than next-generation, high-performance IGT blade alloys). This, in turn, has exhibited high casting yield rates and good application-specific performance, pushing efficiencies to the next level. It's also a more cost-effective solution. Mission accomplished.

NICKEL INDUSTRY PART 3
PROCESSING NICKEL LATERITES HIGH PRESSURE ACID LEACHING

In Part 3 of this series, we look at High Pressure Acid Leaching (HPAL) which is ramping up in capacity to supply battery markets with intermediate nickel materials such as mixed hydroxide and mixed sulphide precipitates, that can be used to make pure nickel sulphate for battery production.

The origins of High Pressure Acid Leaching (HPAL) go back almost 70 years, but the technology is becoming increasingly widespread to supply the demand for nickel-based batteries.

HPAL is conceptually simple: add sulphuric acid and increase the temperature to dissolve the whole ore. Neutralise the excess acid, remove unwanted metals, and recover the desirable metals.

Leaching process

Leaching takes place under high pressure at a temperature of about 250 °C, leaving most of the iron and aluminium contained in the ore in the leach residue, while the valuable materials are in solution. The leaching process, hot and acidic, is extremely aggressive, requiring sophisticated materials like titanium explosion-bonded onto carbon steel — a thin layer of expensive titanium for corrosion resistance and a thick layer of less expensive carbon steel for strength. The wet laterite ore is mixed with water and screened to remove coarse materials, then thickened to be a viscous but still pumpable fluid. The slurry is then heated up to the reaction temperature (>90% of the heating energy is used for the slurry water, not the solids). To reduce the heating costs, the discharge slurries are gradually let down to ambient pressure, generating flash steam which is re-used as the pre-heat source along the way.

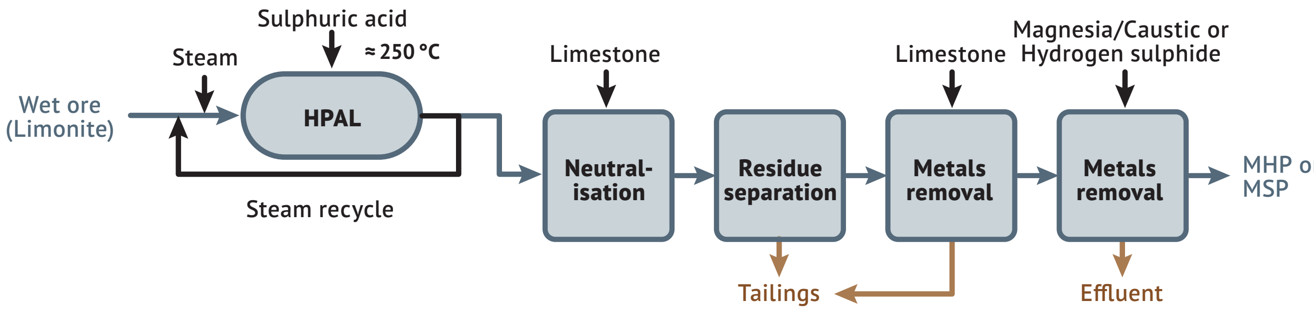
Neutralising excess acid

Before the metals are recovered, the excess acid is neutralised by the addition of ground limestone to form gypsum residue. The mixed residues are washed, usually in a counter-current decantation (CCD) wash, and then deposited as tailings. Standard practice has been to deposit the tailings as thickened slurries in engineered tailings management facilities on land adjacent to the process plant and recycle the liquids released by the settling solids.

Recovering metals

Once the acid is neutralised, the solution contains primarily nickel and cobalt with minor amounts of zinc and copper, alongside more significant amounts of iron, aluminium, and manganese, with a substantial concentration of magnesium. Copper and zinc are not of real economic importance (typically <2% of total value), so may be removed and treated as waste or byproducts. Nickel and cobalt can be recovered in several ways.

HPAL PROCESS



The first HPAL plant was installed at Moa Bay, Cuba in the late 1950s. That one, as well as a handful of subsequent facilities, have opted to use hydrogen sulphide to precipitate a mixed sulphide intermediate (MSP) for refining to Class 1 nickel. MSP is quite pure, dense, and settles well, making it excellent for shipping as it contains about 50-55% Ni + Co shipped as a moist powder. Mixed hydroxide precipitate (MHP) has become very popular in the last 10 years, using caustic or magnesium hydroxide to precipitate a lower-grade intermediate, which contains about 40% Ni + Co, but with much higher moisture (about 50% by weight), meaning the product shipped has only about 20% Ni + Co by weight.

Dealing with effluent

Once the valuable metals (nickel and cobalt) are recovered, a substantial quantity of effluent solution is left, containing significant quantities of magnesium and some manganese as sulfates. Partial recycling is used to conserve water, which builds the magnesium level higher, and ultimately a discharge to eliminate the magnesium from the circuit is required. In arid climates, this solution can be evaporated, leaving the metal sulphates to crystallise in the evaporation pond, while in tropical climates the effluent is discharged to ocean. Before discharge, regulated metals such as Cr, Mn, Ni, and Co should be removed to an acceptable level.

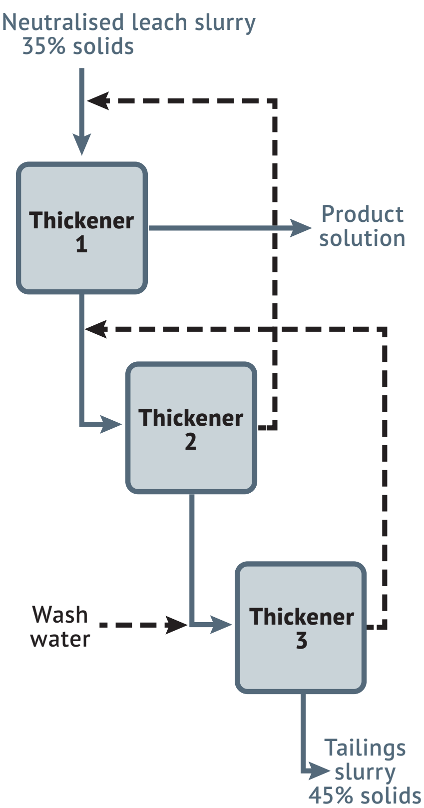
New generation of HPAL

HPAL facilities have been prone to significant startup issues, often related to the challenging conditions which require layered materials of construction, such as the titanium-lined HPAL autoclaves and other rubber or brick-lined vessels and the need to have multiple sequential processing steps all functioning at similar rates. A new generation of these facilities is starting now in Indonesia, and it appears that the experience gained by companies building serial facilities has finally resulted in facilities which work well from day one.

Environmental issues are very different for HPAL facilities than Rotary Kiln Electric Furnace (RKEF): HPAL has relatively low greenhouse gas emissions, especially if sulphuric acid is made on site. However, it does result in substantial processing residues requiring permanent impoundment. The impoundment can be done in ways that minimise risks, but truly eliminating impacts from HPAL residues could only really come with a circular approach to processing which would see these residues re-processed into other materials, such as iron ore or aggregate. This has been examined and remains challenging due to the complex chemistry involved. Ni

Counter-current decantation (CCD) washing is a process where a number of thickeners are used in series to wash the valuable solution away from the residue. In each stage, the incoming slurry from the prior stage is mixed with the wash liquid from the next stage, then thickened and passed on. The last stage is washed with water or other barren solution, which moves up the chain while the solids move down. This process reduces the concentration of valuable materials in each stage by about 50%, so by the time 6 or 7 stages of washing are complete, more than 97% of the valuable materials have been recovered.

CCD WASHING PROCESS



STRATEGIC AND CRITICAL RAW MATERIALS **WHERE DOES NICKEL STAND?**

Certain raw materials are designated as ‘critical’ or ‘strategic’ because they are essential for key industries, economic stability, national security, and technological innovation. Without reliable access to these materials, industries like defence, energy, telecommunications, and electronics could face significant disruptions. Nickel is one such raw material that is receiving attention from governments around the world.

Raw materials form the backbone of virtually all key industrial value chains, from automotive manufacturing and mechanical engineering to electronics - value chains that are essential for economies, industries and civil society.

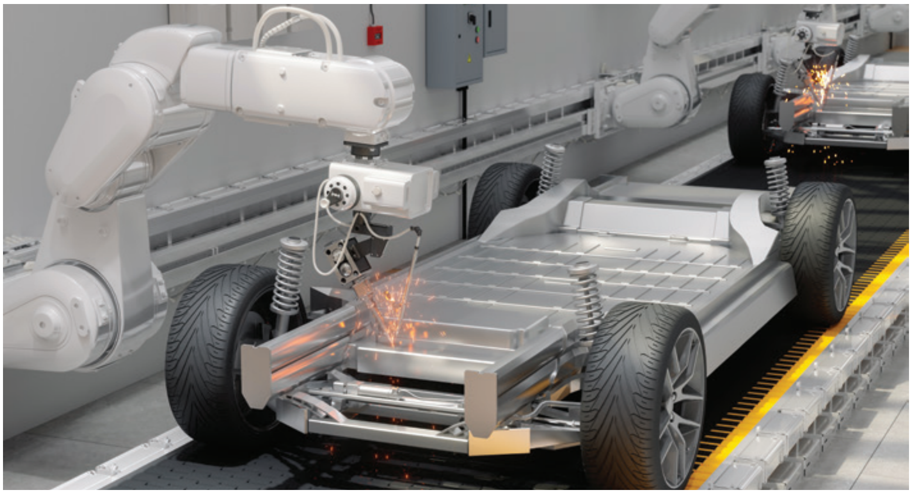
Yet, the significance of these materials often goes unnoticed until shortages occur, which can happen for a multitude of reasons. Imbalances in supply and demand, geopolitical aspects, limited recycling – the reasons for shortages can be numerous.

In the past few decades, shortages of iron ore, coking coal, rare earth elements, magnesite and silicon have disrupted industrial value chains with consequences for entire economies.

In response, the early 2000s saw the launch of ‘criticality assessments’ for raw materials in several regions, notably the United States and the European Union. These assessments aimed to anticipate supply risks and safeguard the continuous flow of essential materials. Today, more than 25 countries conduct such evaluations, identifying raw materials that are vital to their economies and industries and determining measures to mitigate supply risks.

Defining the criticality of raw materials

But how is the criticality of raw materials defined? The criteria for determining whether a raw material is ‘critical’ vary somewhat across jurisdictions, but the underlying principles remain largely consistent. Most assessments hinge



on two key factors: supply risk and economic importance. A raw material is deemed critical when it plays a significant role in essential industrial value chains, yet faces potential disruptions in supply. These supply risks often stem from the geographic concentration of production in a few countries or companies, the volatility of trade relations, insufficient recycling infrastructure, or the absence of viable substitutes.

Critical versus strategic

Increasingly, a second term is gaining attention in this context – 'strategic' raw material. In the European Union 'strategic' is used to describe raw materials that are important but not considered 'critical' as there are currently no supply risks.

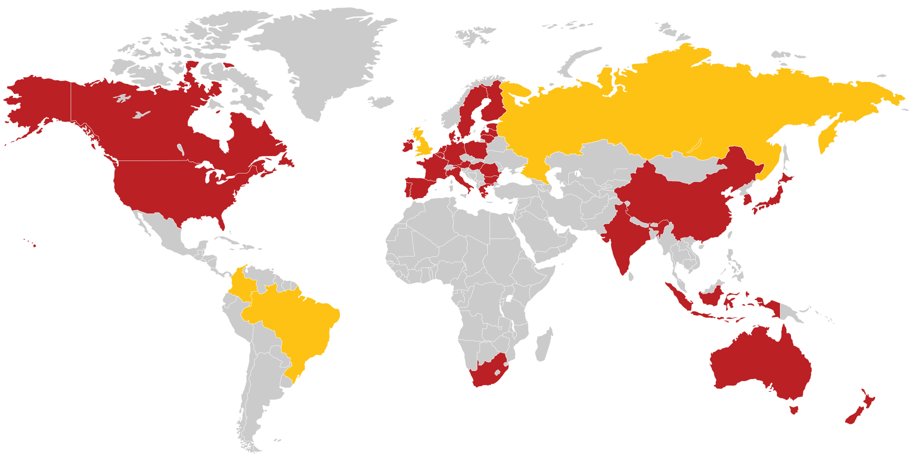
Nickel is widely regarded as a 'critical' material across many regions, with the United States, Canada, China, and Japan among the most prominent examples. But why? Its critical status stems from its pivotal role in the energy and digital transitions, particularly as a key component in electric vehicle (EV) batteries and low-carbon power generation technologies. As demand for these technologies grows, so too does the importance of nickel. In the EU, nickel is regarded as both a 'strategic' and 'critical' raw material. This reflects not only its current economic importance but also its expected centrality in the future.

Implications of critical or strategic status

But is there a benefit for the nickel industry from its products being considered as 'critical' or 'strategic'? The growing recognition of the need for nickel has led to a variety of measures aimed at ensuring secure supply. Governments have begun to streamline permitting processes to encourage domestic production, invest in recycling technologies, and engage in diplomatic efforts to secure access to nickel-rich regions. For the nickel industry, these policy actions can translate into greater support for mining, processing, and recycling initiatives, as well as increased research and development funding.

Critical and strategic

As a metal with exceptional properties – such as resistance to corrosion and high-temperature strength – nickel plays an irreplaceable role in modern societies. Its use in everything from infrastructure to cutting-edge technologies cements its position at the heart of the global economy. It is therefore both a critical and strategic raw material that plays an essential role, both now and in the future. Ni



Critical Materials Assessments (CMA)

Critical

Strategic

POWERING THE FUTURE:
ADVANCES IN NICKEL-BASED BATTERIES

Nickel is playing a part in many key developments announced in recent months in EV and power battery applications.

With the rapid growth of electric vehicles (EVs), the spotlight is on improving the performance, safety, and cost-efficiency of their batteries. At the heart of this innovation is nickel, a critical material in many EV battery chemistries.

Nickel is used in various formulations of lithium-ion batteries, helping to enhance energy density, and therefore improving vehicle range. It is a vital component in NMC (nickel-manganese-cobalt) batteries, which are widely used in EVs. These batteries offer a balance between energy density, thermal stability, and cost. As automakers aim to extend their driving range, there has been a trend toward increasing the nickel content in NMC cathodes.

Tesla

Tesla, for example, has announced a shift to an NMC 955 composition (90% nickel, 5% manganese, 5% cobalt) for its batteries, replacing the previous NMC 811 design (80% nickel). This adjustment is expected to further boost the energy density of its battery cells while slightly reducing reliance on cobalt. Moreover, Tesla is also experimenting with an NMC 973 variant (90% nickel, 7% manganese, and 3% cobalt). The increased nickel content in these chemistries allows for higher capacity and greater range, but balancing the safety and longevity of these cells remains a technical challenge.

More efficient cathodes

Among the key breakthroughs in nickel-based batteries is the advancement of cutting-edge cathode materials and more efficient production processes.

Novonix, a leader in battery materials, has introduced an all-dry, zero-waste method for synthesising nickel-based cathodes. This innovative process significantly reduces the environmental impact of battery manufacturing by eliminating the need for solvents and generating no waste. Moreover, this technique enhances the performance of the cathode material, making it more efficient and sustainable.

Balancing high energy and stability

LG Energy Solution (LGES) is also contributing to the progress with plans to mass-produce high-voltage, mid-nickel batteries by 2025. These batteries are designed to offer a balance between high energy density and stability, essential for EVs.

Another significant development in the EV battery sector is Panasonic's mass production of the 4680 cylindrical lithium-ion battery. This battery format, which offers five times the capacity of the traditional 2170 cell, is set to revolutionise the EV industry by extending vehicle range and reducing the overall number of cells required in a battery pack. The 4680 cells incorporate a high percentage of nickel, further contributing to energy density improvements.

Panasonic's Wakayama factory in Japan will be the primary production hub for the 4680 battery. The company is integrating advanced production methods at this facility, which will also serve as a demonstration site for global manufacturing. The 4680 cell is expected to significantly lower EV production costs, making electric vehicles more accessible to a broader market.

Nickel-zinc batteries

While nickel remains a critical material for high-performance EV batteries, alternative chemistries are also being explored. ZincFive, a leader in nickel-zinc (NiZn) battery solutions, is expanding its operations in the United States to produce batteries for immediate power applications. NiZn batteries are gaining attention due to their high-power output and inherent safety advantages over lithium-ion batteries. These batteries are particularly useful for applications that require quick bursts of power, such as data centres or grid storage.

Though NiZn batteries are not yet viable for large-scale EV deployment due to their lower energy density compared to lithium-ion batteries, their safety and environmental benefits make them an attractive option for certain applications.

Solid-state

Looking ahead, solid-state batteries which replace the liquid electrolyte in conventional lithium-ion cells with a solid electrolyte, promise to deliver greater energy density and enhanced safety. Mercedes-Benz is collaborating with Factorial to develop solid-state batteries under the 'Solstice' project. These batteries are expected to increase energy density by 80% compared to current lithium-ion technology, thanks in part to advances in cathode materials, including nickel-rich compositions.

Nickel at the core

As the electric vehicle industry continues to grow, the role of nickel in battery technology is becoming increasingly prominent. From high-nickel cathodes used by Tesla to LGES's high-voltage mid-nickel cathodes, nickel is at the core of innovations that promise to extend range, improve performance, and lower costs. At the same time, advancements in safety additives, alternative chemistries like NiZn, and the push toward solid-state batteries offer a glimpse into the future of safer, more efficient EV batteries. Ni

FACTORIAL ENERGY

Solid-state batteries are expected to increase energy density by 80% compared to current lithium-ion technology, thanks in part to advances in cathode materials, including nickel-rich compositions.

NICKEL SHINES
AT HIGH TEMPERATURE

ROLLED ALLOYS

These trays are used to stack gears that will undergo a carburising heat treatment at 925 °C (1700 °F) followed by a neutral hardening at 845 °C (1550 °F). The fluted vertical posts are extruded wrought RA330® alloy, that replaced cast alloy posts which had a short life due to inability to straighten because of their low ductility.

Various heat treatments are key to optimising properties of components in the automotive, aerospace, energy, and other industries. This is now of major interest for electric vehicles, as heat-treated components are critical to improved performance with lower weight to increase driving range.

The 300 series nickel-containing stainless steels and nickel-based alloys are the go-to materials for fixtures in heat treatment furnaces. Carburising – diffusing carbon into the metal surface – and nitriding – similar but with nitrogen – heat treatments provide steel with a hard, wear-resistant surface while maintaining a strong and ductile core. Nickel-containing alloys in trays, belts, and other fixtures allow for longer life through numerous cycles. These materials have higher strength at elevated temperatures, retain ductility, and perform well in oxidising atmospheres. They are available in different forms, are easy to fabricate, and weld. High-temperature nickel-based alloys are considered a continuation of the 300 series, with improved properties needed in more extreme conditions.

Both castings and wrought materials are used for high-temperature services. Castings are close to the final shape and may have high carbon content for enhanced creep strength. Alloy HK40 (UNS J94204) has 0.35–0.45% carbon, while Type 310S (S31008) has 0.08% carbon. Both contain 25% Cr and 20% Ni, so perform similarly otherwise. Castings tend to be thicker-walled than wrought products, which may be beneficial in many applications, though weight concerns may arise. Weldability can be an issue with castings due to a larger grain size, but it is generally manageable. High-temperature alloys can be produced by sand, investment, or centrifugal casting methods.

Wrought materials, i.e. plate, sheet, pipe, bar, etc., are designed for welding and fabrication into components. Their lower carbon contents aid weldability, especially when repairs are needed. All designs must account for metal expansion at high temperatures to avoid distortion. Alloy 330 (N08330) is commonly used in heat treating, offering oxidation resistance, ductility, and silicon for carburising environments. Wrought alloys may contain elements like cerium and nitrogen to improve creep strength, oxidation resistance, and metallurgical stability.

As a rule, nickel-containing alloys shine in almost all high-heat applications. Ni

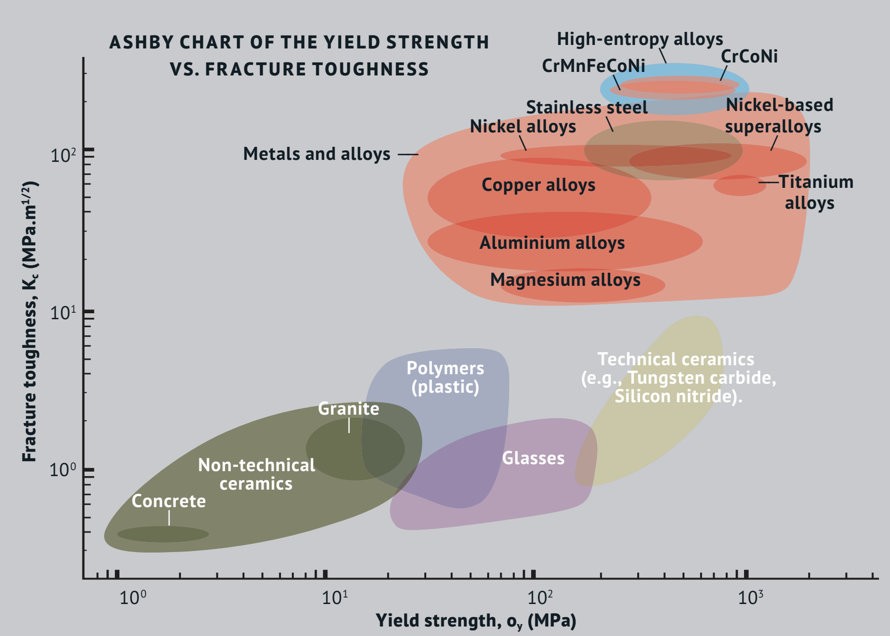
HIGH-ENTROPY ALLOYS

In conventional alloy design, one primary element – such as iron, copper, or aluminium – is chosen for its properties. Then, small amounts of additional elements are added to improve or add properties. The simplest example is steel, which is an alloy of iron (~99%) and carbon (up to ~1%). Carbon greatly enhances strength. A more complex alloy would be Type 304L stainless steel (UNS S30403) with an approximate composition of Fe 72%, Cr 18%, and Ni 8%. The Cr and Ni are essential for producing a corrosion-resistant steel alloy that is easy to fabricate.

In 2003, researchers discovered a new class of alloys, now known as high-entropy alloys (HEA), composed of equal atomic amounts of five or more elements. The initial investigation worked with an alloy composed of CoCrFeMnNi which has been found to have exceptional low-temperature mechanical properties and high fracture toughness, with both ductility and yield strength increasing as the test temperature was reduced from room temperature to -196 °C (−321 °F).

It may have applications as a structural material in low-temperature applications or, because of its high toughness, as an energy-absorbing material.

$Al_{0.5}$CoCrCuFeNi with a small aluminium addition was found to have a high fatigue life and endurance limit, possibly exceeding some conventional steel and titanium alloys. But there was significant variability in the results requiring further investigation. Ni



SOURCE: GEORGE EP, RAABE D, RITCHIE RO. HIGH-ENTROPY ALLOYS. NAT REV MATER 2019;4:515-34.

HEAs are recognised as a class of advanced materials with outstanding mechanical properties and corrosion resistance. Those HEAs containing nickel stand out for their impressive strength, ductility, and oxidation resistance. The high cost of the component metals in these alloys will likely limit their application. But their potentially exceptional properties may provide significant benefits in applications where high-temperature strength and thermal stability are required, such as jet engines and hypersonic vehicles; or automotive applications due to the high strength and toughness; or cryogenic applications due to excellent toughness.

"Ashby plot of yield strength versus fracture toughness showing that CoCrNi-based high-entropy alloys are among the most damage-tolerant materials on record." — Bernd Gludovatz

The axes of the plot are logarithmic, thus 10^2 is 100 times larger than 10^0 showing that HEAs possess a significant increase in yield strength and fracture toughness in comparison to other well-known engineering materials.

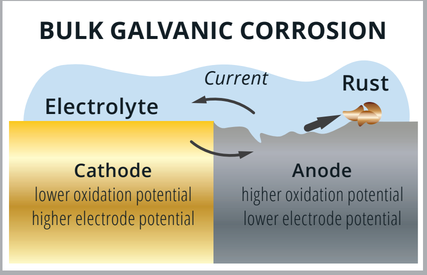
ASK AN EXPERT FAQ FROM THE NICKEL INSTITUTE TECHNICAL ADVICE LINE

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: We are mounting solar panels on a building roof about 2km from the ocean. The mounting brackets are pieces of aluminium that are bolted together with a central bolt made of Type 304 (UNS 30400) stainless steel (no washers, so stainless directly bears on aluminium). Should we be concerned about a dissimilar metal reaction between the aluminium and the stainless steel?

A: For atmospheric exposure like this, stainless steel fasteners are recommended with aluminium alloys to avoid galvanic corrosion of the fastener. The aluminium alloy will provide galvanic protection for the stainless steel, but only if both are wetted and only at the Al-alloy/SS junction.

It is also important to select aluminium and stainless alloys that are intrinsically resistant to the atmosphere. At 2 km (1.24 miles) from the ocean, deposition of salt (sodium chloride) combined with water from rain or condensation can cause pitting/crevice corrosion of some alloys. It depends on how much salt accumulates at this distance from the coast. This is a function of several variables, including temperature, strength and direction of the prevailing wind, frequency of rain, humidity etc.



Ideally Al-Mg (5000 series) or Al-Mg-Si (6000 series) work best in marine atmospheres. On the stainless steel side, 304 can suffer crevice corrosion in marine atmospheres, and 316 (S31600) is a better choice.

With respect to galvanic corrosion, all stainless steels have a similar electrochemical potential and there is no significant difference between 304 and 316. The main factors that affect galvanic corrosion are the area ratio of the two metals and the efficiency of the more noble (positive) metal as a cathode. In atmospheric corrosion the area ratio is mostly 1:1, while stainless steels are not very efficient cathodes when wet in the atmosphere. This is why stainless steel is acceptable as a fastener with aluminium alloys.

If you decide to stick with 304, then an annual inspection of the fasteners would indicate whether corrosion is occurring and how widespread it is. When it becomes too severe, replacement of the affected fasteners will be required. Ni

Nickel can be found in many forms from nanowires to stainless steel alloys. But what are the properties of nickel that make it an essential element in everyday objects?

Why nickel?

NICKEL IN YOUR CHROME FINISHES

Nickel plating might sound fancy, but it's basically a great way to make everyday stuff last longer, stay shiny, and look cool.

So why use it? Nickel makes things tough – it helps stop rust and keeps everything looking smooth and bright, so your favourite gadgets, bikes, and even car parts stay shiny and strong. It's like a protective armour, but also makes things look impressive!

What gets nickel-plated? All sorts of stuff! Think of that shiny finish on bikes, cars, and even taps and showerheads. That's usually nickel underneath, with a thin layer of another metal like chrome or even gold on top.

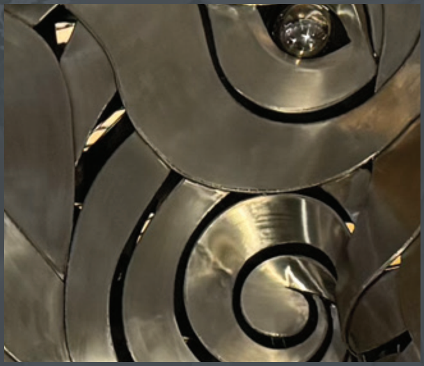
And then there's electroforming, which is like making perfect copies of objects. This can be super useful when we need things to be just the right shape and size – nickel's all about making things work better and last longer!

UNS DETAILS

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

UNS	C	Cr	Cu	Fe	Mn	Mo	N	Ni	P	S	Si
J94204 pg 12	0.35–0.45	23.0–27.0	–	bal	1.50 max	0.50 max	–	19.0–22.0	0.040 max	0.040 max	1.75 max
N08330 pg 12	0.08 max	17.0–20.0	1.00 max	bal	2.00 max	–	–	34.0–37.0	0.03 max	0.03 max	0.75–1.5
S30400 pg 14, 16	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 pg 13	0.03 max	18.0–20.0	–	bal	2.00 max	–	–	8.0–12.0	0.045 max	0.030 max	1.00 max
S31008 pg 12	0.08 max	24.0–26.0	–	bal	2.00 max	–	–	19.0 – 22.0	0.045 max	0.030 max	1.5 max
S32304 pg 2	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	0.030 max	1.00 max

VERONIQUE STEUKERS



THE ELEPHANTS OF SUVARNABHUMI AIRPORT

A symbol of Thai heritage and modernity, two radiant stainless steel elephant sculptures grace the bustling energy of an international hub in Bangkok, the Suvarnabhumi Airport. Somsak Kongnaphakdee, a renowned Thai artist, designed these life-sized sculptures. Fabricated by Vision in Forms (Elephants) and Thapanin (base plate of the sculpture), the Elephant structures were woven from cold rolled stainless steel strips of 1.2 mm thick Type 304-2B (UNS S30400). This method was chosen to reflect the uniqueness of Thai culture's handicraft work.

This pair of stainless steel woven elephants, installed in November 2019, is the only one of its kind in the world.

Material:
1.2 mm thick Type 304-2B

Fabricator:
Elephant sculpture:
Vision In Forms Co., Ltd.
Base plate the sculpture:
Thapanin Co., Ltd.

Artist: Somsak Kongnaphakdee,
Vision In Forms Co., Ltd.

Stainless steel was chosen as the primary material not only for its artistic appeal but also for its resilience, making it ideal for large-scale public art installations. The highly polished finish adds a modern touch, while the subject matter connects with the traditional role of elephants in Thai society as symbols of strength, protection, and royalty. The largest of the stainless steel elephants stands at an impressive 3 m (9.8 ft) tall and weighs around 5 metric tonnes (5.5 tons). The two sculptures have a reflective and sleek appearance that brightens up the airport and draws the admiration of visitors from around the globe.

More than just airport decorations, they have become iconic symbols, inviting travellers to pause, reflect, and appreciate Thailand's intricate artistry and cultural depth. Showcased in Satellite Terminal 1, they are part of a broader effort to integrate art into public spaces. Ni