NICKEL

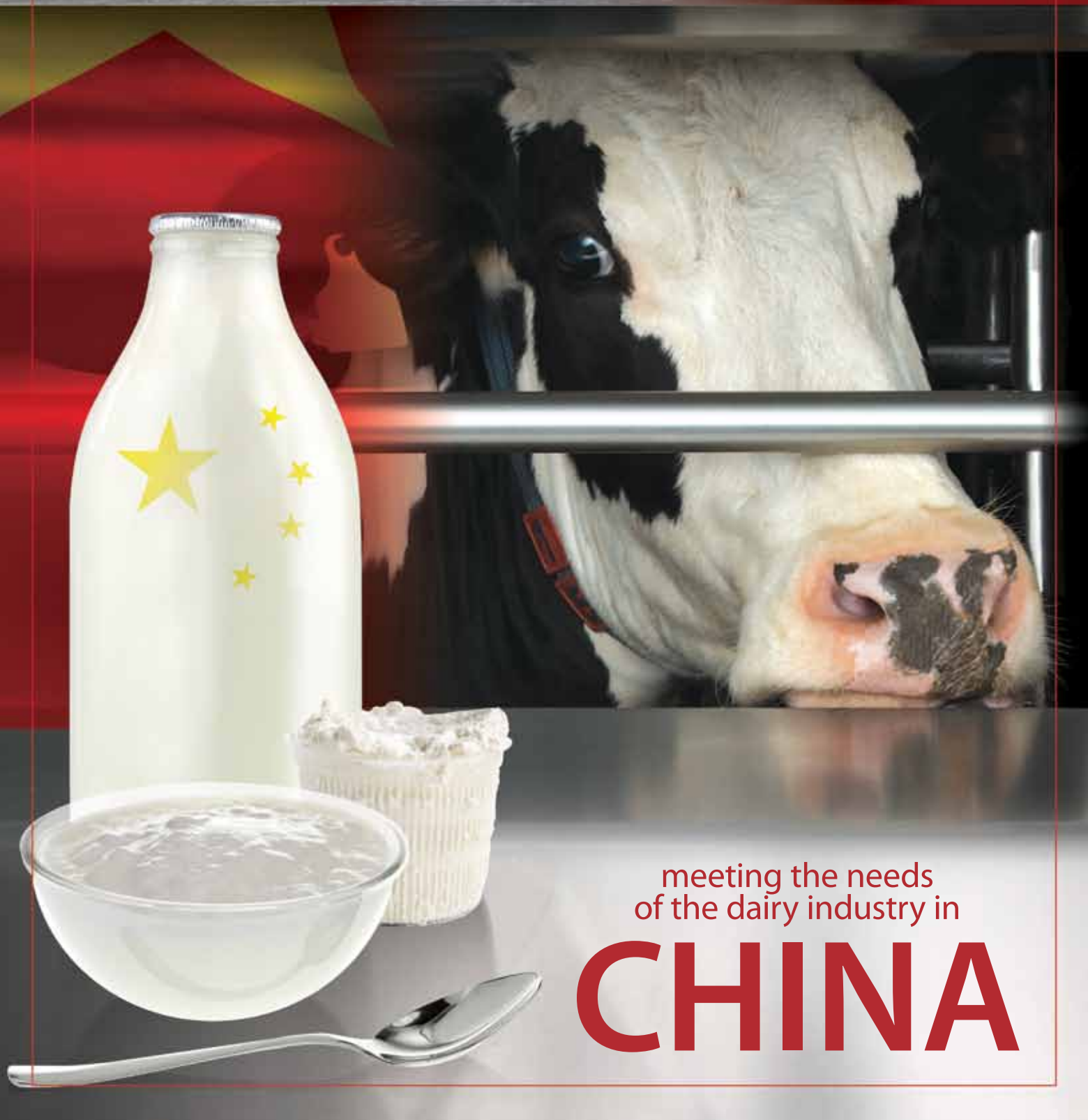
THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

Micro-nutrient nickel: fundamental to ammonia conversion

Multi-ferroic alloys: electricity out of waste heat

Domestic nickel: supporting comfortable living

December 2011 Vol. 26, N°. 2



meeting the needs of the dairy industry in

CHINA

ISTOCK PHOTO © ALEX SLOBODKIN

New and Improved

It's our newly engineered and re-launched website:
fresh user-friendly interface, powerful search function
and crisp presentation of material.

www.nickelinstitute.org

for information on the socially and environmentally responsible
production, use and re-use through recycling, of nickel

Volume 26, Number 2, December 2011

NICKEL

The Magazine Devoted to Nickel and its Applications

Nickel Magazine is published by
The Nickel Institute

Dr. Kevin Bradley, President
Stephanie Dunn, Editor
sdunn@nickelinstitute.org

Constructive Communications, Design

The Nickel Institute can be contacted at:
Eighth Floor
Avenue des Arts 13-14
Brussels 1210, Belgium
Tel. 32 2 290 3200
brussels@nickelinstitute.org

ISSN 0829-8351

Printed on recycled paper in Canada.

Cover:
Photo Composition: Constructive Communications
Cow Photo: Vicki Saunders for the Nickel Institute
iStock Photos: © joingate © fcknimages © paci77
© Dmitry Naumov

TABLE OF CONTENTS

PHOTO COURTESY OF KOHLER. KOHLER'S STACCATO KITCHEN SINK.

DOMESTICATED NICKEL

We know that nickel plays a prominent and innovative role in modern industry. This magazine has consistently covered many of the more dramatic or leading-edge applications, but what of the more ordinary, domestic uses? There is a tendency for these to be overlooked. This issue of Nickel is designed to redress that imbalance.

And what better place to start than the kitchen? There is a place in the kitchen for ceramic and cast-iron bowls and cookware. However, daily meals, whether they are prepared in the home or in restaurants and cafeterias, depend on nickel-containing stainless steel. Cutlery, pots and pans and containers account for only a few of the many kitchen utensils made of stainless. As our story on page 8 explains, nickel also is hidden away in a surprising number of small appliances and electrical units.

Practically all such units can be linked, in one way or another, to what is arguably the most important "appliance" of all: the kitchen sink. Here is where water is obtained for cooking and drinking and where many utensils and small appliances as well as fruit and vegetables will be washed. The life of a sink is a long and hard one. It has to tolerate bumps and abrasions, heat and cold, acids and caustics, and all the while withstand frequent cleaning. We are reminded of how all this is possible in "Kitchen Sink Central" on page 12.

Closely associated with family life both in and out of the kitchen are plumbing fixtures. Wherever there is water and the need to regulate its flow, there is an opportunity for nickel to make a difference. It may be an aesthetic difference (that "brushed nickel" look so popular in recent years or the bright chrome finish that depends on the nickel underneath it) or a practical one (ensuring the toughness, durability and cleanability that are so essential to a healthy family environment). All of which is explored in "Plumbing Fixtures" on page 6.

Other stories that touch on family life show how nickel underpins the safe production of milk which helps build strong bones and teeth "Dairy in China", page 4 and how its use in orthodontic wires helps keep those teeth straight "Nitinol Archwires", page 10.

We also venture beyond the domestic scene to explore the role nickel plays in healthy trees, and looking to the future, in generating electricity from waste heat, as well as what "recycled content" means in the context of metals. What all these articles show is that nickel is in use and at work for a healthy and sustainable life in more ways than can be imagined.

Stephanie Dunn
Editor, Nickel Magazine

For all the

Dairy in China

Nickel-containing stainless steels benefit China's dairy industry

ISTOCK PHOTO: MILK PITCHER © VALENTYN VOLKOV, BABY BOTTLES © MARIA TOUTOUDAKI, ICE CREAM © OKEA, CHEESE © IVONNE WIERINK-VANWETTEN, RICOTTA © PACI77, CHEESE © PETRO KORCHMAR

ISTOCK PHOTO: GIRL © THOMAS PERKINS, MILK BACKGROUND © CRAFTVISION

In a very short time, China has joined the front ranks of the world's dairy producers. Milk output in 2010 reached 37.4 million tons, making China the third-largest milk producing country. The current Five Year Plan (ending in 2013) would see this rise to 48 million tonnes. This in turn has resulted in a dramatic increase in the use of nickel-containing stainless steels in the handling and processing of Chinese milk and milk products.

The explosive growth in the country's dairy production has not been without challenges. Three years ago, public confidence suffered when milk products were discovered to have been adulterated. Chinese milk processors have long been aware of the need for pure, safe products, and the incidents of 2008 strengthened their commitment to quality assurance for milk purity and safety.

"Every manufacturing facility of our member companies is full of stainless steel," says Dr. Zhihui Sun, vice-president of the China Food and Packaging Machinery Industry Association and a professor at the Light Industry School of the Harbin University of Commerce. "They know that, in addition to its long life, stainless steel ensures the safety of milk products. It is easy to clean and hygienic. The Chinese dairy industry depends on stainless steel; they trust it."

Thanks to the use of austenitic stainless steels in milk production, the treatment processes that guarantee a safe and high-quality product have improved, and the increased efficiencies have resulted in lower overall costs for milk products.

Stainless steel is used throughout the entire milk production process, starting with the milking equipment itself. Raw milk flows through stainless steel pipes into stainless steel collection tanks before being transported to stainless steel coolers which cool the liquid to below 4°C. From there, it travels through stainless steel pipes and into stainless steel storage tanks. To produce skimmed milk and butter, milk is transported via stainless steel pipes to a stainless steel separator where separation takes place at temperatures of between 50° and 65°C. In short, all the equipment in the process, including the milk packaging line, is made of stainless.

> "They [the manufacturers] know that, in addition to its long life, stainless steel ensures the safety of milk products."

The many advantages of stainless steel make it an essential – and un-substitutable – material in milk production. Chief among these is cleanability. At each step in the milk production process, equipment needs to be cleaned with hot water. All surfaces on the relevant equipment that come into contact with the milk are stainless steel (except for some rubber parts, which are harder to clean).

The other well-known advantage of stainless steel is corrosion resistance. Hot detergent and disinfectants are used to sanitize the equipment. Such chemicals can be aggressive, which is why nickel-containing stainless steel types 304 (UNS S30400) and 316 (UNS S31600) are employed. Indeed, these alloys have become China's standard materials for product contact surfaces in the entire food industry, not just dairy.

These nickel-containing stainless steels have additional advantages such as long service life, ease of fabrication, and high availability. Also, during the whole process of milk production, storage and distribution, types 304 and 316 protect the milk from being contaminated or changing flavor due to interaction with containers.

There is nickel in the milk, a natural and inevitable constituent as nickel is an essential micro-nutrient for the grasses upon which the cows graze.

Given China's ongoing economic growth and the development food habits, there is no doubt that consumption of milk and milk products will continue to rise – just as there can be no doubt about the increasingly important role nickel-containing stainless steels will play in this and other industries. Ni

ISTOCK PHOTO © TANUKI PHOTOGRAPHY

MIDDLE PHOTOS COURESY OF: 孙智慧 (DR. ZHIHUI SUN) AND 卜退武 (DR. CHIWU BU)

ISTOCK PHOTO © P_WEI

Stainless steel is used throughout the entire milk production process.
Raw milk flows through stainless steel pipes into stainless steel collection tanks before being transported to stainless steel coolers which cool the liquid to below 4°C. From there, it travels through stainless steel pipes and into stainless steel storage tanks.

IMAGE COURTESY OF KOHLER

Plumbing Fixtures

All-stainless: not just for institutions anymore

> ...people looking for luxury bathrooms choose the material "not just for aesthetics but for cleanliness."

Nickel alloys have always made a big splash in kitchens and bathrooms, but the ripples are spreading beyond the stainless steel sinks and nickel-plated faucets found in most homes. The old saying "everything but the kitchen sink" needs updating: think everything and the kitchen sink.

The all-stainless plumbing fixtures commonly found in commercial and institutional settings have migrated into the home, where they're making a bold design statement. Acorn Engineering, based in Los Angeles and one of the largest manufacturers of plumbing fixtures in North America, has redesigned the metal toilets and sinks it built for schools and prisons since the 1950s into a line of fixtures crafted from Type 304 (UNS S30400) stainless.

Acorn's Neo-Metro division produces stainless steel basins set seamlessly into vanity tops, as well as toilets and gleaming tubs, showers and bidets. Electrostatically applied, baked-on finishes in bright primary colours can be added to customize the look.

"My material of choice is stainless steel," says Kristin Kahle, Neo-Metro's director of sales and marketing and the granddaughter of Acorn's founder. Neo-Metro sells to nightclubs, restaurants and hotels but has found a niche market among residential customers drawn to the clean, sleek lines and European styling of the fixtures.

"Over the years stainless steel has been associated with high-end products," Kahle notes, adding that people looking for luxury bathrooms choose the material "not just for aesthetics but for cleanliness." The stainless fixtures typically cost about a third more than comparable models made of vitreous china.

Stainless is also featured in new sink designs for the kitchen. Manufacturers such as Kohler Co., a Wisconsin-based leader in bath and kitchen products, are producing the undermount, apron-front and trough models favoured for today's kitchens. The traditional counter-top mounted kitchen sink has been updated, with Kohler now offering the Swerve™ model, which features a graceful curved profile, and the Verity® model, with a rectangular basin that rises several inches above the countertop.

When it comes to faucets, nickel-plated brass was the go-to combination a century ago, but the metal coating tended to wear off over time. It was replaced by tougher chromium plating. Nickel experienced a renaissance, according to Kohler, thanks to the development of an improved finishing process known as physical vapour deposition (PVD), which produces a coating that's more durable and abrasion-resistant than chrome. Polished and brushed nickel finishes have recently become two of the most popular choices for kitchen and bathroom faucets. (The latter has a matte finish which hides water spots and fingerprints.)

Kohler makes a futuristic, high-tech toilet, an integral component of which is stainless steel. The remote-controlled Numi™ toilet has a retractable stainless bidet wand for cleansing and drying which is programmable and self-cleaning.

Nickel remains a popular choice for bathroom accessories. For instance, TOTO of Japan, the world's largest manufacturer of plumbing products, offers an array of designs of towel bars and rings, robe hooks and paper holders in brushed and polished nickel. That's in addition to the firm's line of plumbing fittings, shower heads and faucets, including its new EcoPower™ line of hands-free, water-saving faucets. Ni

Images Opposite ▷

1. *Constructed of heavy gauge stainless steel, this unique Japanese soaking bath design by Neo Metro is perfect for an outdoor bathroom application.*
2. *MiniLoo: This attractive "mini" toilet is perfect for small spaces. By Neo Metro.*
3. *Kohler's Bachata® undermount lavatory sink.*
4. *A one-piece constructed tub that features double wall insulation to keep the water temperature constant for hours by Neo Metro.*
5. *Numi toilet's retractable stainless bidet wand.*
6. *Ebb design, satin finish stainless steel basin with wall-mounted resin deck by Neo Metro.*

◁ *Kohler's high-tech Numi toilet.*

1.

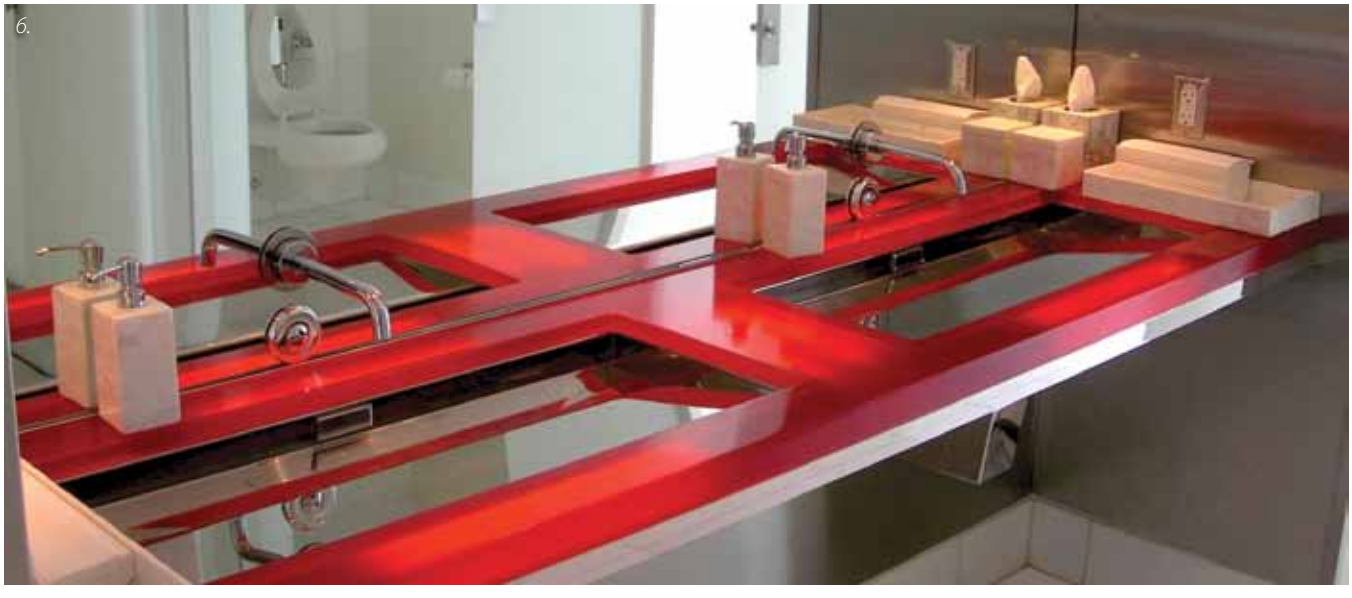
2.

3.

4.

5.

6.



HOME IS WHERE THE NICKEL IS

How nickel helps support comfortable living

Take a quick look around any home and you're sure to see plenty of examples of products made from stainless steel and other nickel alloys.

They gleam on the exterior panels of kitchen appliances, bring polished brightness to sinks and faucets, and add cleanliness and durability to the pots and pans, flatware and utensils tucked away in drawers and cabinets. Take a closer look and you'll find stainless inside the dishwasher, in the drum of the clothes dryer, and even hard at work on the patio, protecting the gas barbeque from the elements.

But these are only the most obvious applications of nickel alloys in the consumer goods we use every day – and they barely scratch the shiny surface of the way nickel-containing materials are used in today's homes.

"There are a lot of applications that are invisible and not well-known to the public," notes Pascal Payet-Gaspard, Secretary-General of the Brussels-based International Stainless Steel Forum (ISSF). "The mechanical properties and durability of stainless steel make it functional as well as beautiful."

Consumer goods are a growth sector for stainless steel producers. Finnish manufacturer Outokumpu, in its 2010 annual report, notes that stainless consumption in the catering and appliance sector increased even during the poor economy of 2009. Global demand in the consumer sector increased another 14% in 2010, with higher growth rates in the emerging markets of China and India.

A study by the German metals market research firm Heinz H. Pariser estimates that electrical products accounted for slightly more than 12% of nickel production (some 155,000 tons) in 2009, much of it in the form of stainless steel for major home appliances. About 5% of total production was used in alloy form to build electronic components, exploiting nickel's conductivity, magnetic and shielding properties, as well as its contribution to corrosion resistance.

Nickel is found in the heating coils and elements of common electric appliances such as clothes irons, hot plates, toaster ovens, grills, electric blankets, baseboard heaters, and soldering irons. These chromium-nickel alloys can contain from 20 to 80% nickel, and some can resist oxidation and maintain their shape at temperatures up to 1,250°C (2,280°F).

Low thermal expansion nickel-iron alloys which contain between 36 and 42% nickel, for example Invar® (UNS K93600), have long been used in bi-metal strips for thermostats and other temperature-control devices. They're also found in small appliances such as irons and toasters, in electronic components, and computer monitors.

Nickel plays a key role in the manufacture of disk-shaped data-storage platters in computer hard drives. The aluminum platter is plated with a nickel-phosphorus alloy, which is then polished to ensure it is perfectly smooth before magnetic data-recording layers are applied.

Other uses of nickel are closer to hand. The metal cases of cellular phones and other external parts are often now made of stainless steel. One of the latest BlackBerry models, the Bold 9900, is encircled in a rim of stainless steel that incorporates control buttons, while the Acer Liquid E Metal smartphone, released in 2011, features a stainless back that is coated to resist fingerprints. Payet-Gaspard points out that stainless steel is almost certain to be found in many of the internal electronic components of computers, phones, tablets and other high-tech devices.

> "The mechanical properties and durability of stainless steel make it functional as well as beautiful."

Nickel-containing stainless steels are favoured for a host of other everyday items, from the tiny springs in wristwatches to earrings in the bedroom to the heads of the golf clubs stored in the garage. The ISSF's website (www.worldstainless.org) notes myriad other uses, including belt buckles, pens, flashlight casings, key rings, watch backs and straps, hot water tanks, and swimming pool filters and fixtures.

Nowhere is stainless more prevalent than in the kitchen. A technical paper prepared for Outokumpu notes that the high demands placed on corrosion resistance and hygiene in food preparation make stainless steel "the obvious choice of material" for kitchenware.

But the use of stainless in the kitchen is expanding beyond major appliances, sinks, and pots and pans, and in a high-profile way. Homeowners and interior designers seeking the modern, sleek look of commercial kitchens are selecting it for countertops, backsplashes, shelving, islands, carts, range hoods, and even for cladded or all-metal cabinetry. "It's fashionable to have a modern kitchen made of stainless steel," says Payet-Gaspard.

Indiana-based Stainless Steel Kitchens (www.stainlesssteelkitchen.com), for instance, custom-builds cabinets for indoor and outdoor kitchens and reminds consumers that stainless alloys are recyclable, non-toxic, and an ideal choice for people with chemical sensitivities. And the web site www.kitchens.com, which tracks design trends, points out that the silver-grey of stainless serves as a neutral backdrop, reflecting light and colour from other elements of a room.

Some of that gleam can be added to any room through an array of household items. An online retailer, www.thestainlesssteelstore.

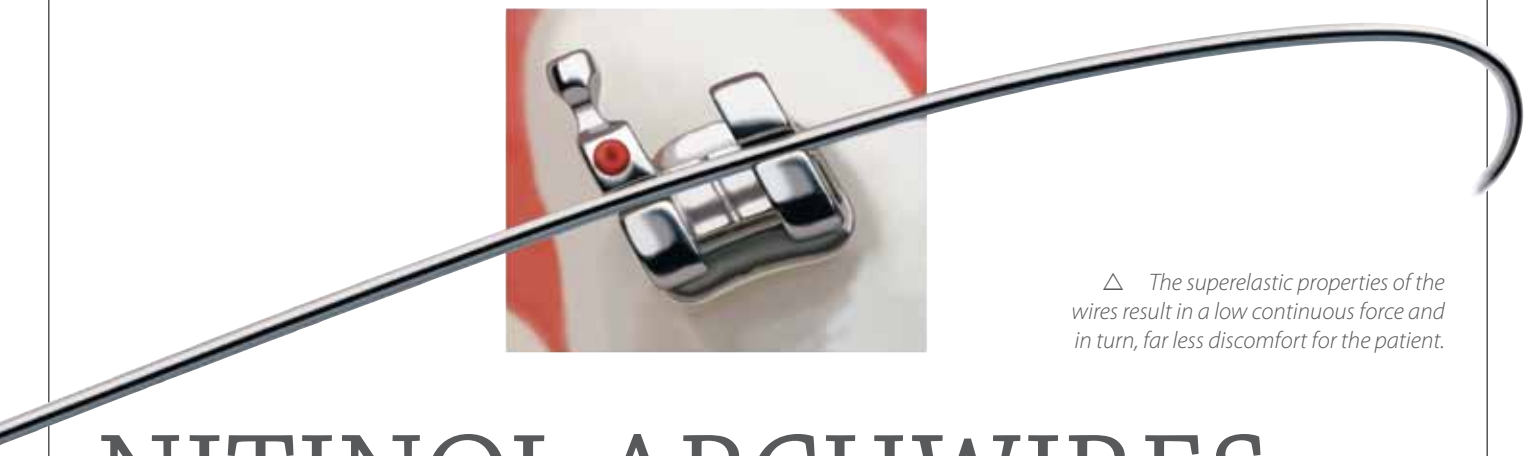
STAND MIXER IMAGE KITCHENAID™, U.S.A.

com, offers scores of products in stainless steel, from umbrella stands, wine racks and hip flasks to bird feeders and watering cans for the garden and even a stapler for office use.

Manufacturers continue to find new uses for stainless in the home. The 2011 edition of the ISSF's Book of New Applications features cookware for herbal medicine and a rice washer, both in Type 304 (UNS S30400), as well as sleek, European-designed patio furniture with tubular frames of polished Type 316 (UNS S31600) stainless. There's also a German-made glass display case with a sturdy frame of cold-rolled stainless – a perfect showcase for nickel-containing alloys. Ni

LOUNGE CHAIRS IMAGE COURTESY OF: NAUTINOX LIVING

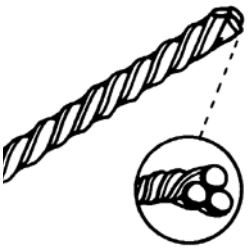
ISTOCK PHOTO: HOUSE © ANA VASILEVA, IRON © PAVEL KONOVALOV, TOASTEROVEN © ANGELO GILARDELLI, POTS © UMIT EMRE GUNGUT, DATA PHONE © ALEX SLOBODKIN, THERMOSTAT © GORDON BALL, APPLIANCES © ALXPIN , CD © EMILIO GELOSI



△ *The superelastic properties of the wires result in a low continuous force and in turn, far less discomfort for the patient.*

NITINOL ARCHWIRES
PROVE THEY HAVE TEETH

Celebrating a nickel-titanium breakthrough in orthodontics



The introduction of superelastic Nitinol® (UNS N01555) wires in the field of orthodontics more than a decade ago was an "unbelievable blessing," says Dr. Robert Cram, past president of the Canadian Association of Orthodontists. Superelastic wires stretch easily when they are cool but spontaneously shrink when they are warmed up. This property can be used to progressively pull teeth into their proper position.

Nickel-titanium archwires, typically composed of 54.5-57% nickel and 43-45.5% titanium by weight, have mostly replaced the stainless steel braces once used to straighten or correct teeth for cosmetic or clinical reasons. Sometimes small amounts of copper or other elements are added to the alloy to enhance the heat-activated process that allows the wires to shrink to their original shape when warmed up by body heat.

"What a wonderful invention," says Cram. "We were always having to tinker with all sorts of variations of stainless steel to get the right flexibility, but we could never get the shape memory effect."

Another significant benefit of superelastic wires is that they don't cause nearly as much discomfort as stainless steel braces. That's because the wires exert a slow, steady pressure rather the intense, instantaneous force produced when tightening conventional braces. When an archwire is placed in a patient's mouth, its temperature rises to ambient body temperature, causing the Nitinol to contract to its original length with a low, continuous force, gradually pulling the teeth into position.

"In the old days, we changed the archwires every four weeks, and when we put in a stainless steel wire, you could have severe pain for two to three days," recalls Cram, "whereas the new wires can be left in for twenty weeks before you have to change them."

As a result, monthly visits to the orthodontist have been replaced by quarterly ones.

Although superelastic wires are several times more expensive than stainless steel braces (effectively doubling orthodontic costs for a similar procedure), the time and discomfort saved are worth the added expense, says Cram. He uses superelastic wires in 99% of his cases, using nickel stainless steel only if the dental work requires expanding the patient's arch.

Other applications of superelastic Nitinol in orthodontics include correcting uneven spacing by moving teeth up to 6 mm in six months and applying torsional forces to turn twisted teeth back to their correct orientation. Ni

PHOTOS COURTESY OF 3M UNITEK

NICKEL CHLORIDE

$NiCl_2$ – Versatile High Volume Chemical

This is the last of a series of four articles spotlighting nickel chemicals. Previous articles covered nickel hydroxycarbonate, nickel sulphate and nickel hydroxide.

Description

As with most nickel chemicals, the common nickel chloride hexahydrate ($NiCl_2.6H_2O$) varies from pale to emerald green in crystal or liquid form. Nickel chloride is strongly hygroscopic and will absorb available water from the air to the point of becoming liquid (deliquescence). The anhydrous form is pale yellow in colour. Nickel chloride is also sold in liquid form.

Production

Nickel chloride is one of four nickel chemicals classified as "high production volume chemicals," which indicates annual production in excess of 1,000 tonnes. The others are nickel sulphate, nickel nitrate and nickel hydroxycarbonate. The global production of nickel chloride is estimated at 12,000 tonnes (2002), calculated as $NiCl_2$.

A natural rare form of nickel chloride – nickelbischofite – exists but is of no commercial significance except to collectors of minerals.

There are various commercial production routes for nickel chloride, including the dissolution of other nickel-containing chemicals such as nickel oxide (NiO) or nickel hydroxycarbonate ($NiCO_3$) in hydrochloric acid. The main production process involves putting finely ground nickel matte (a smelter nickel/copper intermediate product) through a series of steps to separate and purify the nickel chloride as well as other elements of economic interest. Nickel chloride can also be produced from nickel metal by acid dissolution of nickel metal, followed by solvent extraction, purification and crystallisation. The key agent may again be hydrochloric acid or a leaching process based on ferric chloride.

End Uses

Approximately 75% of all nickel chloride is used as a precursor in the production of catalysts with a variety of properties (Danish $NiCl_2$ Risk Assessment Document, p.21). Of these catalysts, the greatest percentage will be used in "cracking" petroleum fractions (cracking being the process whereby complex molecules are broken down into simpler ones). The most familiar such catalyst is named after its inventor: Raney Nickel catalyst.

About 2% of nickel chloride is used in making pigments and mordants (dyeing or fixing of colour in fabrics) or else as intermediate material for other specialty chemicals (Danish $NiCl_2$ Risk Assessment Document, p.21). The remainder goes into metal finishing.

Nickel plating can be achieved through a number of routes, not all of which make use of nickel chloride (though the major processes do include it). Nickel plating may be carried out for reasons of, increased corrosion protection, increased wear resistance, reduced co-efficient of friction, greater fatigue strength of parts, or aesthetics.

Plating baths that include the use of nickel chloride are known for the speed with which nickel is deposited on target parts and for good current distribution (the rate and amount of nickel deposited are not affected by where the part is located in the bath). All-chloride nickel plating can operate at relatively low voltages, generate thick coatings, resist pitting, and result in surfaces that polish well.

Historically, nickel chloride has been used to control fungus on several plantation crops, notably tea, though this practice is declining with the advent of modern organic agricultural fungicides.

The Risk Assessment on nickel chloride prepared by the European Union with industry assistance and the nickel chloride REACH registration dossier are the best and most recent publicly available source of additional information.

http://www.nickelinstitute.org/Sustainability/EnvironmentalQuality/NickelRiskAssessment.aspx
http://apps.echa.europa.eu/registered/registered-sub.aspx

Ni

NICKEL CHLORIDE $NiCl_2$

Synonyms:
Nickelous chloride, nickel dichloride, nickel (II) salt of hydrochloric acid

Nickel content:
59.5% (anhydrous);
~24.3% (commercial hexahydrate)

CAS number:
7718 54 9 (anhydrous) and
7791 20 0 (hexahydrate)

EINECS number:
231 743 0
(anhydrous and hydrated forms)

Molar mass:
129.5994 g/mol (anhydrous) and
237.69 g/mol (hexahydrate)

Appearance:
light green

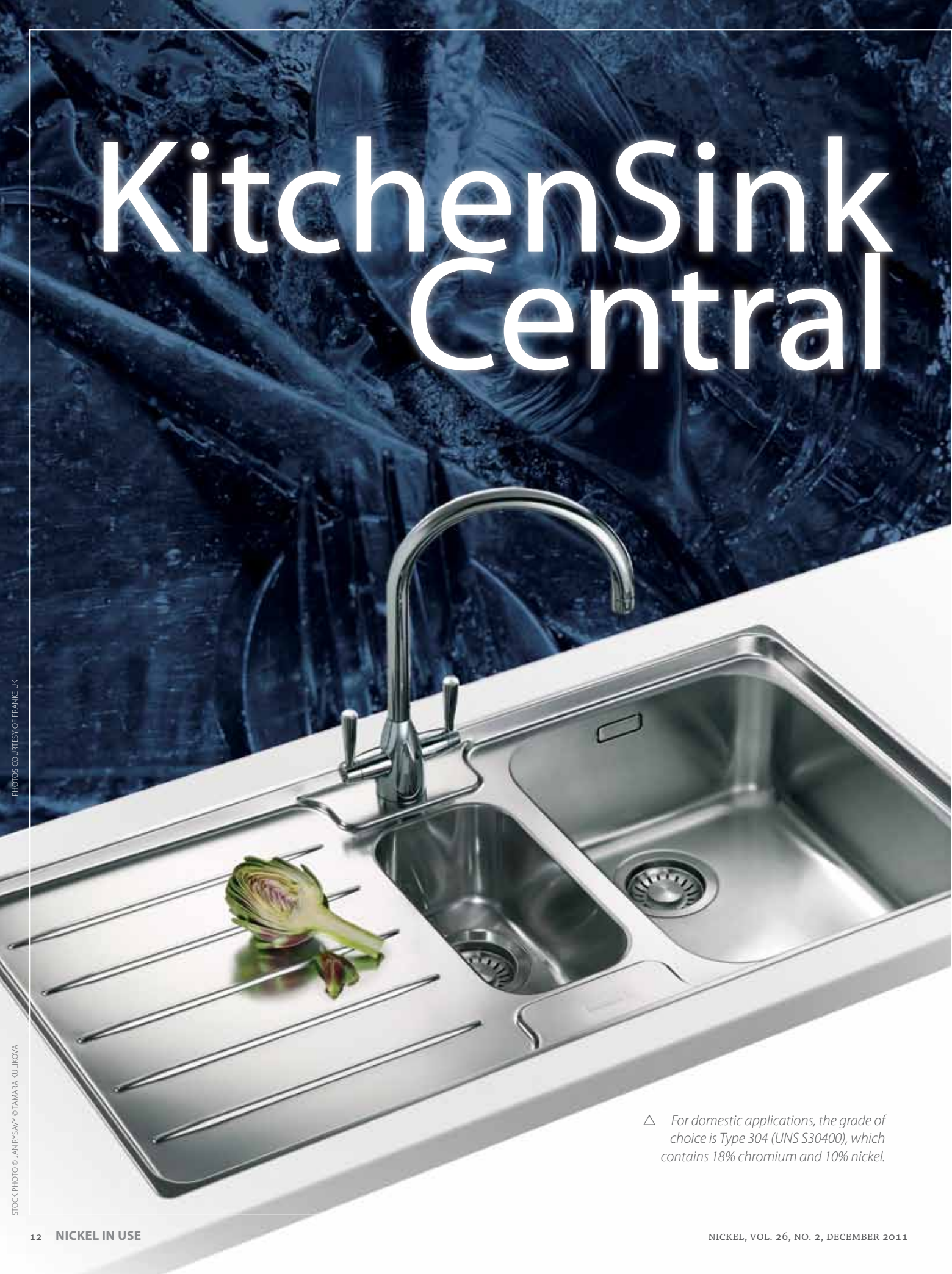
Relative density (20°C):
3.55 g/cm^3 (anhydrous) and 1.92 g/cm^3 (hexahydrate)

Melting point:
1,001°C (anhydrous); loss of water of crystallization: 140°C (hexahydrate)

Water solubility (20°C):
64.2 g/100 mL (anhydrous) and
254 g/100 mL (hexahydrate)

Close up of Nickel chloride hexahydrate ▷

KitchenSink Central



PHOTOS COURTESY OF FRANKE UK

ISTOCK PHOTO © JAN RYSAVY © TAMARA KULIKOVA

△ *For domestic applications, the grade of choice is Type 304 (UNS S30400), which contains 18% chromium and 10% nickel.*

Nickel-containing stainless steel kitchen sinks are valued around the world for their ability to withstand intense, everyday use

If asked to name the most important part of one's home, most people would say the kitchen. After all, we all need to eat to survive, and the kitchen is where we store our food, wash it, and prepare it for consumption.

And at the centre of every kitchen is the sink, perhaps the single most intensively used of all household appliances. Today most domestic and industrial sinks are made from nickel-containing stainless steel and exhibit long-lasting beauty and decades of service.

The result is that on average the stainless steel we use is 90% recycled material...and of course the sinks themselves are 100% recyclable at the end of their long life.

"Stainless steel works extremely well in terms of standard, everyday usage, which is what's required of a kitchen sink regardless of the various foodstuffs and cleaning chemicals used in the kitchen," says Eric Partington, European consultant to the Nickel Institute.

Many stainless steel sinks are constructed from a pressed top surface of stainless steel into which is welded a deep-drawn bowl. It is in no small part the nickel content of the material selected that is responsible for the ease and consistency of forming and welding.

Most domestic and industrial sinks are manufactured from premium-quality chromium/nickel stainless steels. For domestic applications, the grade of choice is Type 304 (UNS S30400), which contains 18% chromium and 10% nickel.

Partington notes that in a more demanding industrial environment such as may be associated with the preparation of salty foods, grade Type 316 (UNS S31600), which contains 2% molybdenum, may be more appropriate. Although more expensive, the molybdenum does afford the steel greater corrosion resistance, particularly to chlorides.

Frank Brazda, Executive Vice-President and General Manager of Novanni Stainless Inc., a manufacturer of kitchen sinks in Coldwater, Canada, says "the nickel contained in the 300 series provides the mechanical properties that allow us to deep-draw and form the material to the shapes we require. Deep drawing induces a high level of stress into the steel so it must remain highly ductile."

Nickel-bearing stainless steels are not only used for domestic sinks. They are the materials of choice for almost all food-processing equipment the world over and are recognized as preferred materials by groups such as the European Hygienic Engineering & Design Group and the American 3-A Standards Inc. Type 304 is the base grade, with Type 316 and even higher alloys used for more demanding applications. The 300 series are used industrially because of their resistance to attack from most foods, even at higher temperatures, their resistance to disinfecting solutions, and their cleanability.

"One of the biggest advantages in the use and application of nickel-containing stainless steel sinks is corrosion resistance," says Novanni's Brazda. Sinks can be made in lower alloyed stainless steels but they do not have the same high corrosion resistance as Type 304."

Although not strictly necessary for hygiene, a polished stainless steel surface complements the high standards appropriate both to the retail environment and the domestic kitchen, which is why most manufacturers will polish the surface of their fabricated sinks to a fine finish.

A major advantage of stainless steels over softer materials such as certain synthetics is their hardness, which enables them to resist deep scratching. Scratches and gouges in a sink can harbour micro-organisms as they are less accessible to detergents. Stainless steel sinks remain hygienic and easy to clean.

Another important benefit of nickel-containing stainless is its recyclability, something which is not lost on Novanni. "The stainless steel we use to make our sinks is made almost entirely from scrap material, mainly old stainless steel," notes Brazda. "To this is added whatever chromium or nickel that is needed to ensure that the new stainless steel meets specifications. The result is that on average the stainless steel we use is 90% recycled material...and of course the sinks themselves are 100% recyclable at the end of their long life."

There are hundreds of manufacturers of nickel-containing stainless steel sinks in the world and their global popularity continues even as alternative materials for sinks come into and fall out of fashion. The beauty, durability and functionality of stainless steel sinks, however, just goes on and on until, in time, they make their own contribution to recycling. Ni

Stainless Steel Recycling

It's what's recycled that counts, not the recycled content

PHOTO COURTESY OF NOVANNI JED1935D8U

Novanni Sinks: The stainless steel used is 90% recycled material and the sinks themselves are 100% recyclable at the end of their long life.

The marketplace is full of products that refer to their recycled content. Paper is probably the most easily recognized, where phrases such as "made from 100% post-consumer material" appear on the packaging. Yet metal products such as the Novanni sinks (see "Kitchen Sink Central" page 12) that refer to their recycled content are rare.

"Recycled content" is an easy-to-understand concept and can be a measure of the "eco-efficiency" of the material in the product. "Eco-efficiency" is the concept of creating goods and services while using fewer resources and creating less waste and pollution. As such, it is attractive to lawmakers and there is a temptation to mandate "recycled content" within the regulatory system for all materials and products. Regrettably this is another example of how "one size fits all" can be unhelpful.

It is not by accident that "recycled content" is most commonly used for paper or plastic products. When such a product reaches the end of its life, its fate will be either recycling into new materials for further use, combustion (for energy recovery), or landfill.

Clearly "further use" is the preferred option. Yet there is a trade-off: the qualities of the original materials are degraded to a greater or lesser extent every time they are recycled, and often once is the practical limit before the material properties are degraded to the point where there is no residual utility or value.

Put another way, it is the "down-cycling" (the process of converting waste materials or useless products into new materials or products of lesser quality and reduced functionality) of these materials that provides the "recycled content."

In this context, metals have an advantage since they are quite literally recycled – stainless steel scrap becomes prime stainless steel. So why is the Novanni example so rare?

Availability: Demand for austenitic stainless steel products continues to increase while the end-of-life material that could contribute "recycled content" to new stainless steel remains in service and unavailable. This is an excellent reflection of the durability, strength and corrosion resistance of stainless steel, but it doesn't help feed the furnaces that are making stainless steel today.

Geography: Novanni's austenitic stainless steel comes from the plant of a single supplier in an area in North America that, in stainless steel terms, is "mature." That means stainless steel has been in use and increasing in volume there for many decades. Consequently, there is a reliable and significant stream of scrap becoming available to the stainless steel manufacturer and, from there, to Novanni.

With this understanding, the best way to measure the eco-efficiency for stainless steels is not the "recycled content" of any particular stainless steel sink but the global percentage of all the stainless steel that becomes available for recycling that is actually recycled. That global average is about 70% and rising.

Within that global and environmentally relevant percentage, however, there will be stainless steel sinks with "recycled content" that varies enormously. It doesn't matter: it's all stainless steel, it's all recyclable, and it's all good. Ni

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

Alloy	C	Co	Cr	Fe	H	Mn	Mo	N	Nb	Ni	O	P	S	Si	Ti	Other
K93600 p. 8	-	-	-	64	-	-	-	-	-	36	-	-	-	-	-	-
N01555 p. 10, 15	0.07 max	0.05 max	0.01 max	0.05 max	0.005 max	-	-	-	0.025 max	54.0-57.0	0.05 max	-	-	-	rem	-
S30400 p. 5, 9, 13	0.08 max	-	18.00-20.00	-	-	2.00 max	-	-	-	8.00-10.50	-	0.045 max	0.030 max	1.00 max	-	-
S31600 p. 5, 9, 13	0.08 max	-	16.00-18.00	-	-	2.00 max	2.00-3.00	-	-	10.00-14.00	-	0.045 max	0.030 max	1.00 max	-	-

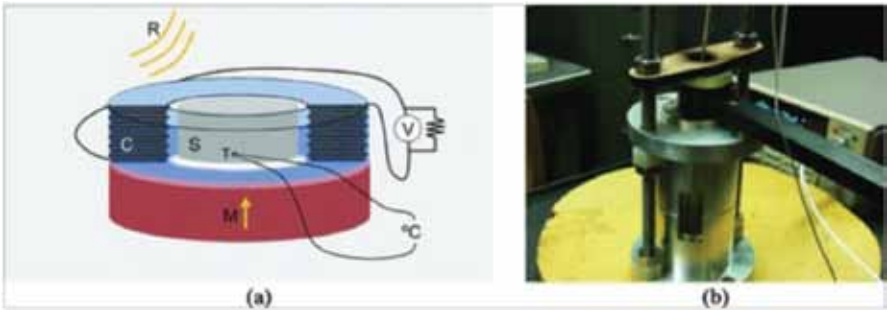
Hot Idea

Researchers use nickel-containing multi-ferroic alloys to make electricity out of waste heat

It is the dream of researchers to find a way of efficiently converting heat from waste sources into useful electricity. University of Minnesota researchers may be on the right track following the development of a multi-ferroic alloy containing 45% nickel that permits just such a conversion.

Ferroic alloys are materials that, at a specific temperature, undergo a sudden phase change which in turn produces a significant change in their ferro-magnetic, ferro-electric or ferro-elastic properties. Changes in two or more of these properties will occur in multi-ferroic alloys. The most commonly used ferroic alloy is the family of nickel-titanium Nitinol (UNS N01555) alloys, that can have either superelastic (see article on orthodontic archwires, page 10) or shape-memory properties at room temperature, depending on their nickel-titanium ratio.

The University of Minnesota alloy, which, in addition to 45% nickel, contains 40% manganese, 5% cobalt and 10% tin, exploits the ferro-magnetic properties. This alloy has a non-magnetic martensitic structure up to the critical temperature at which it rapidly transforms to a ferro-magnetic austenitic structure. In the presence of a strong permanent magnet, this phase change induces an electric current in a surrounding coil.



Schematic (a) and actual (b) views of the demonstration. C, coil; R, heat source; S, specimen of Ni45Co5Mn40Sn10; M, permanent magnet with direction of magnetization indicated; T, thermocouple; V, voltmeter. From http://onlinelibrary.wiley.com/doi/10.1002/aenm.201000048/pdf Advanced Energy MaterialsVolume 1, Issue 1, pages 97-104, 15 DEC 2010 DOI: 10.1002/aenm.201000048.

While many materials will undergo such a phase change and property changes, one of the key attributes of this particular alloy is its low hysteresis during the heating/cooling cycle. This means only a small change in temperature is needed to cause the phase changes to occur in either direction.

There are many possible sources of waste heat that could be used by this process to generate electricity. These include heat from automotive exhaust systems, heat from electronic equipment (including computers), and heat from power plants and industrial plants that today either goes up a stack or passes through a heat exchanger into the lakes or oceans. The electricity generated would be environmentally friendly. Not only would no emissions be produced in the process, but heat that today is being wasted would be utilized.

Commercialization of the technology is some ways off, but once again, nickel is shown to be playing a key role in the development of green energy. Ni

ISTOCK PHOTO © JAMES BREY

Essential Nickel

Naturally-occurring, micro-nutrient nickel fundamental in ammonia conversion

Successful growth and development of plants needs nickel. That's partly because nickel is an essential micro-nutrient in the conversion of urea to ammonia and thus in the mobilization of nitrogen.

Nickel is present in all soils and only a small amount is required for urea conversion, so incidents of nickel deficiency are rare. Some plants, like the pecan tree are especially reliant on the presence of nickel. Without enough nickel, the enzyme that converts urea to ammonia can't function, so urea can accumulate to a concentration that harms the tree. Nickel deficiency in pecan trees can produce physical deformations, reduced crop yield (e.g. premature fruit-drop, reduced photosynthesis, and greater scab disease susceptibility) and reduced survivability.

The deficiency may be due to a low level of nickel in the soil, or to relatively high alkalinity or a high level of zinc, copper, or iron, all of which can inhibit nickel uptake or metabolism.

Happily there is a simple cure as shown in a research report entitled "Nickel and Plant Disease" produced by the United States Department of Agriculture. Spraying a mixture of nickel (nickel lignosulfonate) and a nitrogen-containing fertilizer directly onto the foliage of pecan trees restores them to health and productivity. The authors, Drs. B.W. Wood and C.C. Reilly, conclude that "Today, Ni is most aptly described as 'the forgotten essential trace element'!" Ni

Physical evidence of nickel deficiency in pecan trees:

◁ *Left: One tree but two results when only part of the tree was sprayed with nickel lignosulphonate.*

△ *Above: The health and vigorous growth of one branch contrasts sharply with foliage that did not receive supplemental nickel.*

PHOTOS COURTESY OF BRUCE WOOD

ISTOCK PHOTO © KEVIN DYER, © KATHY HICKS