NICKEL

Volvo's quest for lightness

Livermore Lab's super-clean laser

FEBRUARY 2003 VOLUME 18, NUMBER 2 THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

Super-Jumbos

How Nickel alloys will help get them off the ground

WHY YOU SHOULD BE READING

www.nickelmagazine.org

This is just one sample article of an online article at www.nickelmagazine.org ("Ultra-light Stainless" p.10). View extra photographs, links and information not included in the print edition of Nickel.

Stay up-to-date

Read about the latest applications of nickel at www.nickelmagazine.org. Articles are posted to our website as soon as they're written, weeks or even months before the printed version arrives via post.

Save Time

Subscribe to the *Nickel* Magazine e-mail list and receive a brief summary of new articles with a handy link to each one, as soon as they go online. One click takes you directly to the HTML page.

Get more information

Articles on *Nickel* Magazine's website often will contain additional text, photographs, charts and links to related documents, that won't fit into the printed version. The "More Info" section at the bottom of each article allows you to directly contact the individuals or companies mentioned in the article.

Have a closer look

One click on most photographs at *Nickel* Magazine's website allows you to view a larger more detailed version. We also include many photographs on the website that don't fit into the print edition of *Nickel*.

View related websites and documents

Related articles, technical reports, company websites and e-mail contact addresses are provided at the end of each *Nickel* article you read online.

Search for any topic by keyword

No more looking endlessly through back issues for an article you read months ago. Just use the keyword search at www.nickelmagazine.org to find information quickly on any topic from a previous issue of *Nickel*.

View previous issues of Nickel

We're hard at work moving *Nickel* issues over to our new website. Very shortly you will be able to search and view the last 20 issues of *Nickel*.

Printable HTML & PDF versions

All pages of *Nickel* Magazine Online have quick links to "easy to print" versions of articles in both HTML and PDF formats. So it's simple to make a hard copy of a *Nickel* article for your files or to pass along to a colleague.

No Spam, no junk mail

NiDI's privacy policy is simple. We keep your information confidential and you can unsubscribe at any time.

Sign-up for *Nickel* Magazine Online today!

All you need to do is enter your e-mail address at
www.nickelonline.org/subscribe
and you will start receiving our monthly e-mail summary of links to *Nickel* articles as soon as they're online.

Published by

NiDI Nickel Development Institute

http://www.nidi.org

For additional information on how to contact us, please see page 3.

NICKEL

Volume 18, Number 2, February 2003

The Magazine Devoted to Nickel and its applications

Nickel is published three times per year by
The Nickel Development Institute
214 King St. W., Suite 510
Toronto, Canada M5H 3S6
Tel. 416 591 7999
Fax 416 591 7987
Website: www.nidi.org
E-mail: nidi_toronto@nidi.org

Ivor Kirman, President
Patrick Whiteway, Editor

Circulation, 32,000 in 95 countries

Other NiDI offices:

Europe
42 Weymouth St.
London, England W1G 6NP
Tel. 44 20 7258 9830
Fax. 44 20 7487 4964
E-mail: nidi_london_uk@nidi.org

European Technical Information Centre
The Holloway, Alvechurch
Birmingham, England B48 7QB
Tel. 44 1527 584777
Fax. 44 1527 585562
E-mail: nidi_birmingham_uk@nidi.org

Japan
11-3, 5-chome, Shimbashi,
Minato-ku, Tokyo, Japan
Tel. 81 3 3436 7953
Fax. 81 3 3436 2132
E-mail: nidi_japan@nidi.org

Central & South America
Nucleo Inox
Av. Pedroso de Moraes, 240 – Conj. 22
São Paulo 05420-000 – SP, Brazil
Tel: 55 11 38130969
Fax: 55 11 38131064
E-mail: nucleoinox@nucleoinox.org.br

India
K-36, 1st Floor
Hauz Khas Enclave,
New Delhi 110 016, India
Tel. 91 11 686 5631, 686 3389
Fax. 91 11 686 3376
E-mail: nidi_india@nidi.org

Australasia
150 Drummond St., Suite 3
Carlton, Victoria, Australia 3053
Tel. 61 3 9650 9547
Fax. 61 3 9650 9548
E-mail: nidi_australia@nidi.org

South Korea
Olympia Building - Room 811
196-7 Jamsilbon-Dong, Songpa-Ku,
Seoul 138 229, South Korea
Tel. 82 2 419 6465
Fax. 82 2 419 2088
E-mail: nidi_korea@nidi.org
Website: www.nidikorea.org

China
Room 677, Poly Plaza Office Building
14 Dongzhimen Nandajie
Beijing, China 100027
Tel. 86 10 6500 1188 (ext. 3677)
Fax. 86 10 6501 0261
E-mail: nidi_china@nidi.org

Subscriptions: To be added to our distribution list free of charge or to notify us of a change-of-address, visit our website at www.nidi.org and click on "subscriptions."

ISSN 0829-8351

Printed on recycled paper in Canada.

Cover: The freight version of the Airbus 380.

The next issue of Nickel Magazine will be published in June 2003.

On the road since 1936

MOST YEARS, ALLEGHENY LUDLUM DISPLAYS AN UNUSUAL CAR IN ITS booth at the annual NACE International conference in the United States. This model (six of which were built by Allegheny and Ford in 1936) is made entirely of nickel stainless steel and has been dubbed "the cars that wouldn't wear out."

In terms of fuel use, however, the car is inefficient by today's standards. What it demonstrates is not low weight, but the durability of stainless steel. But that's not to say nickel stainless steel will never be used to build fuel-efficient cars.

ALLEGHENY LUDLUM

STAINLESS STEEL CAR. Built to last, but not very fuel efficient by today's standards.

In today's world, the impact the transport industry has on the natural environment is directly related to the amount of energy required to move people and goods using available technology. More specifically, the amount of fossil fuels consumed per person-kilometre or per tonne-kilometre of goods being moved is directly proportional to the amount of greenhouse gases emitted into the atmosphere and the amount of non-renewable fossil fuel resources that is depleted.

To achieve the greatest reduction in these environmental impacts, transportation engineers strive to improve the fuel efficiency of their creations. One of the simplest ways to do so is to reduce the weight of airplanes, cars, trucks, trains and ships without compromising safety (that is, crashworthiness). One story in this issue refers to efforts to reduce the weight of the new, 555-passenger Airbus A380 by using composite materials (page 8), while another discusses how the weight of other transportation vehicles can be reduced by employing a new hybrid stainless steel material invented by Volvo (page 10). Both technologies require nickel-containing alloys.

There is another, less-explored way for engineers to reduce the environmental "footprint" of the transportation industry. It requires that they select materials that have the lowest possible impact on the natural environment as a result of the production of a final product from raw materials. The method for getting a handle on this is known as life-cycle assessment, and is an important consideration in the construction of transportation infrastructure.

Take concrete reinforcing bar (rebar) as an example. More than five years ago, some innovative engineers started specifying stainless steel reinforcing bar in concrete structures such as highway bridges and marine piers. Using stainless steel in these applications means that the rebar exposed to chlorides does not corrode; therefore it does not impair the structural integrity of a concrete structure, which is what would happen if carbon steel rebar were used. As a result, concrete bridges last much longer and do not need to be repaired as often. Simply put, less material is needed, and so the environmental impact associated with the end product is greatly reduced. In recent years, an increasing number of structures have been constructed using stainless steel rebar. One such application appears on page 5.

Safety also plays an important role in materials selection, as is illustrated by another transportation-related article, on page 13. It describes the rehabilitation of an important transportation link between Italy and France—the Mont Blanc tunnel. Nickel stainless steels were used extensively to improve the safety systems in the tunnel following a fatal fire in 1999.

If you happen to be in San Diego, California, for the annual NACE conference in March, drop by the Allegheny Ludlum booth to see the car that wouldn't wear out. And come visit us at booth 1212 while you're at it. We'd be happy to discuss these and any other nickel-related issues with you.

Patrick Whiteway

COLOURED STAINLESS steel will be used to clad three 40-metre-high gnomons in Derbyshire, England

DESIGNERS Adam Walkden and Richard Swain chose nickel stainless steel for its durability, versatility and recycling potential.

£1.2-million U.K. Solar Pyramid

Will feature mirror-polished, green-coloured S31600 stainless steel cladding

The world's largest working sundial, a pyramid clad in "coloured" stainless steel, is expected to mark the longest day of the year when it opens on June 21st, 2004.

The 40-metre high "solar pyramid," a confluence of vertical triangular planes, will dominate the skyline adjacent to the M1 motorway in Derbyshire, England (just a few kilometres, incidentally, from where stainless steel was discovered 90 years ago by Sheffield metallurgist Harry Brearley).

The design consists of three gnomons, or planes, constructed of mild steel and inclined towards each other at an angle of 53° to create a pyramid shape. The gnomons will tell time by casting shadows across a 50-metre-wide stone and brick piazza.

What sets the sundial apart from most metal sculptures is the cladding: a mirror-polished, coloured S31600 stainless steel developed by Rimex Metals, a specialist in metal finishes and one of the sponsors of the project.

The designers of the solar pyramid, Adam Walkden and Richard Swain, chose the material for its durability and versatility. They also appreciate the way the mirror finish reflects the perpetual changes in land and sky.

"The illusion of colour created by the process captured our imaginations and seemed perfect for this situation," says Walkden. "The ability to silkscreen images and logos onto the material was also important," he adds.

Rimex Metals' Colourtex process does not use paints or dyes, says Rimex representative Keith Wilson, but instead takes advantage of the passive oxide layer that gives stainless steel its corrosion resistance. By immersing the steel in a hot solution of chromic and sulphuric acid, Rimex increases the thickness of this oxide layer, thereby enhancing the natural phenomenom of light interference and creating colour. For a simple analogy, imagine the colours generated when oil floats on water.

Rimex produces a range of colours, including champagne, black, blue, gold, red and green, depending on the thickness of the oxide layer. The company can also adjust the appearance of the steel from matt (dull) to lustrous by adjusting the surface texture. In any case, the steel remains colourfast, even when exposed to the elements.

The ColourTex process enhances the cladding on several other architectural projects worldwide, including the Experience Music Project in Seattle, Washington, U.S.A., a Frank Gehry design inspired by the bright hues of electric guitars. On this building, red and blue painted aluminum is interspersed with 10,000 square metres of stainless steel shingles in red and gold to create a myriad of colours designed to symbolize the energy and fluidity of music.

Walkden says construction is scheduled to begin in April, 2003 and finish in time for the summer solstice on June 21st, 2004. About one third of the £1.2 million needed for the project has been contributed by sponsors. Fundraising for the remainder is ongoing, and the designers are still seeking a major sponsor interested in having the pyramid bear its name.

MORE INFO: www.nickelmagazine.org/0203/4.htm

RIMEX METALS

Oregon Bridge Uses Stainless

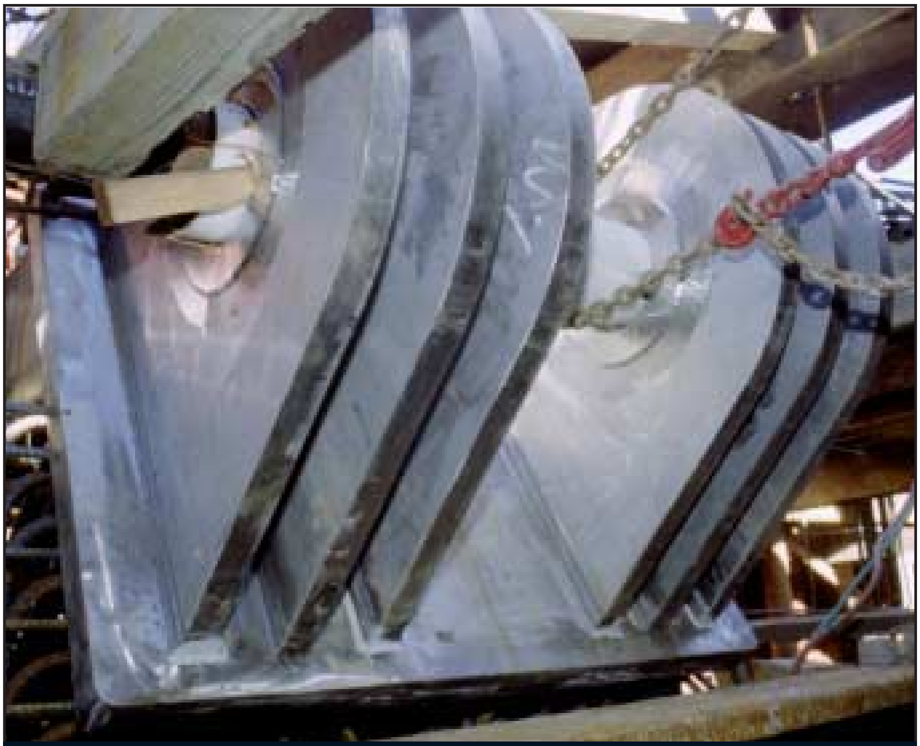
A highway bridge in Oregon that uses duplex stainless steel, is designed to last 120 years

The state of Oregon in the northwestern United States is using S32205 stainless steel as an antidote to the corrosion problems that plague some of its older bridges along the Pacific coastline.

A US$12-million bridge now under construction over an estuary near Coos Bay will contain 363 tonnes of stainless steel rebar, believed to be the largest quantity of stainless steel used for any bridge in North America.

The Oregon marine environment is hard on bridges reinforced by carbon steel rebar. Wind blows salty, moist air under the deck and T-beams, where it condenses and causes corrosion. The resulting cracking along the contact between the rebar and the concrete is exacerbated by tensile cracking caused by heavy traffic loads. Eventually, rust forms and the concrete begins to crumble, weakening further the bond between the metal and the concrete. Structural failure has been known to occur in as little as 17 years.

Usually, designers recommend S31653 or S30400 stainless steel to prevent these problems. But Oregon has gone a step further. By choosing the S32205 alloy, which has much greater corrosion resistance, the state hopes to extend the maintenance-free life of the bridge to 120 years while providing the structure with enough strength to withstand potentially damaging seismic activity in the earthquake-prone area.



IN ADDITION TO 365 TONNES of S32205 rebar, the Coos Bay bridge features massive hinge assemblies made of S21800 (8.5% nickel) at the butt of each arch rib.

The S32205 was supplied by Carpenter Technology Corp. of Reading, Pa., U.S.A. It contains 22% chromium, 5.5% nickel and 3% molybdenum. The alloy has superior fatigue resistance because it exceeds the elongation requirement that allows bridges to withstand movement and stress under heavy truck traffic. Its yield strength is also considerably higher than the 410 megapascals typical of S31653 and S30400 stainless.

Even though the state stands to save a considerable amount on maintenance costs by using S32205, the choice of material did not add significantly to the capital cost of the project. The rebar represents only about 13% of the US$12 million budget.

"The designer, James Bollman, decided to use a stronger reinforcing bar than usual, to reduce the total weight and cost, of the stainless steel," says Frank Nelson in the bridge engineering section of Oregon's Department of Transportation. "At the 520-megapascals yield strength, the steel mill and the contractor agreed on using this specific alloy.

Another, much larger (614-tonne) tonnage of uncoated carbon steel rebar will support areas of the substructure where corrosion is less of a concern. The 235-metrelong bridge, a series of three spans of concrete deck arches, will carry an estimated 14,000 vehicles per day. The five-lane structure replaces a two-lane timbered bridge that has reached the end of its life and is being removed.

MORE INFO: www.nickelmagazine.org/0203/5.htm

Sweden's First All-Stainless Bridge

Corrosion-resistant duplex stainless steel helps beautify Stockholm's newest suburb

Spanning the Sickla Canal in the new residential area of Hammarby Sjöstad, in the southern part of Stockholm, Sweden, is a shiny new bridge for pedestrians and cyclists. The design, by three Swedish architects Erik Andersson, Jelena Mijanovic and Magnus Ståhl, is called Apaté (a Greek word meaning 'mirage'). In 1998 it was the winning entry in an international design competition.

The footbridge is 62 metres long, constructed of 80 tonnes of duplex stainless steel S32205, and resembles a bow or harp with the chords underneath. The load-bearing portion comprises an arched central box girder with a triangular cross-section and tensioning cables fixed in the concrete foundations at both ends of the bridge. The handrails are made of tubes of the same grade of stainless steel and have built-in lighting. Only the walkway is coated with asphalt, the rest being welded stainless steel. Plate thicknesses vary from 8 to 20 millimetres.

The designers opted for stainless steel in order to create a sense of harmony with the surrounding architecture. The additional materials costs (compared to typical mild steel) are expected to be at least partially offset overtime by greatly reduced maintenance and painting costs.

By Sten von Matern, a Sweden-based consultant to the Nickel Development Institute. **More info:** www.nickelmagazine.org/0203/5b.htm

STEN VON MATERN/NIDI

ORIN RUSSIE/ODOT PHOTO/VIDEO

HIGH STANDARDS of cleanliness dictated that nickel-containing S30400 stainless steel be used in the target chamber of the NIF laser (left). The US$2.5-billion laser will be 200 metres long and 85 metres wide (right).

New 'Super Clean' Laser to Study Fusion

Nickel stainless steel is a critical material in what will become the world's largest, most powerful laser

A 192-beam laser system is being designed at the Lawrence Livermore National Laboratory in Livermore, California, U.S.A. and, upon completion in 2008, will be installed at the nearby National Ignition Facility (NIF).

Designed to unravel the intricacies of fusion, the mammoth laser will also play a role in the United States Department of Energy's science-based Stockpile Stewardship Program. The mandate of the program is to assure the safety and reliability of the country's nuclear weapons. Experiments involving the NIF laser will advance our knowledge in the fields of astrophysics, hydrodynamics and material properties, while also advancing the pursuit of fusion as a possible source of energy.

Budgeted at US$2.5 billion, the laser will be about 200 metres long and 85 metres wide, roughly the size of a modern sports arena. More than 11,500 tonnes of nickel-containing stainless steel have already been used, primarily to support the target chamber. The laser's ultimate goal is to direct 1.8 million joules of ultraviolet laser energy in a few billionths of a second on to targets to study inertial fusion and high-energy-density physics.

More than 1,000 scientists, engineers, designers and technicians have worked on the laser's construction, which began in 1997.

The NIF laser system begins as a single laser pulse on the order of a nano-joule, which is then further amplified and split into 192 ten-joule pulses. The pulses enter the main laser system, where each laser beam is transported in a fully enclosed beam-path containing mirrors, lenses, amplifiers,

TARGET CHAMBER: More than 11,500 tonnes of nickel-containing stainless steel have been used for structural support

switches and spatial filters. S30400 stainless steel, containing 8% nickel (minimum), plays an important role in maintaining cleanliness inside the laser at Class 10, Level 80, or better.

Clean room Class is currently defined by International Organization for Standardization (ISO) Standards 14644. The numerical value of the Class refers to the number of particles within a specific size range suspended in the air inside a clean room. Class 10 means that there are less than 10 particles greater than 0.5 micrometre in size per cubic foot in the air and is comparable to the best clean rooms used by the semiconductor industry. For comparison, the air in a typical office building might be Class 100,000.

The higher the airborne concentration of particles, the faster they will settle out onto surfaces. Level 80 is an indication of the number of particles on surfaces. Like the airborne concentration, the surface cleanliness Level is defined as the number of particles per square foot on a surface with a particle size exceeding a stated size. A Level 80 surface would have about 2,200 particles greater than 1 micrometer per square foot and is considerably cleaner than what can be seen with the unaided eye even with excellent lighting conditions.

Lou Bertolini, one of NIF's mechanical engineers, stresses that S30400 stainless steel is a critical component in keeping the laser system free of contaminants. "Cleanliness of NIF's optical components is crucial to prevent damage from the intense laser energy inside each beam enclosure," he says.

Passivated stainless steel can be washed with an organic solvent or cleaned with very clean water and a detergent. In addition, iron oxide, which could damage the laser glass, does not form on passivated stainless steel.

NIF and its various components, including stainless steel enclosures and structural support, is designed to last 30 years.

MORE INFO: www.nickelmagazine.org/0203/6.htm

LAWRENCE LIVERMORE NATIONAL LABORATORY

China Opts for Fine Screening

Corrosion-resistant stainless steel used for waste water treament plants designed to last 25 years

BOUND FOR CHINA: Three rotating drums, made of S31600 stainless steel, near completion in Auckland, New Zealand prior to being shipped to a waste water treatment plant in Shenzen, China.

The eyes of the world will soon be on Beijing in 2008 when it hosts the 29th Olympiad, and one aspect of daily life that will not go unnoticed is how China manages its water resources.

The Chinese government is determined to improve the quality of water in many regions and, toward that end, has financed projects designed to improve methods of cleaning effluent that goes into local rivers, lakes and seas.

Many foreign companies are racing to offer various water treatment technologies to China, among them an environmental engineering firm in Auckland, New Zealand—Contra-Shear Separation Technologies Ltd.

The company recently received a NZ$1-million contract to supply fine screens for the Nan Shan waste water treatment plant in the city of Shenzen, in the southern province of Guangdong. The plant will treat sewage generated by a city of 4.5 million.

Fine screening of sewage below 6 millimetres is a relatively new concept in many countries. By removing most of the inorganic matter in the primary stage, the fine screening process reduces the amount of solids released downstream. Contra-Shear has been supplying such systems to waste water treatment plants worldwide for more than 15 years.

As a part of the contract, Contra-Shear will supply and commission four patented Suboscreens® made entirely of S31600 stainless steel, and an integrated solids handling system.

The Suboscreen is a semi-submerged rotating drum. The units for Nan Shan have a drum diameter of 1.75 metres with a slot opening of 4.5 millimetres. Each unit is designed for a peak flow rate of 1,900 litres per second. Total plant capacity will be about 500 million litres per day.

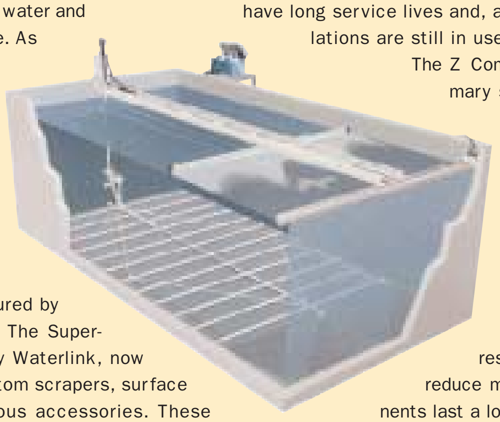
"Sewage applications for Suboscreens generally require S31600 stainless steel, as it is more resistant to corrosion," says John Phillips, regional manager for Contra-Shear. "Although we use S30400 in other applications, we prefer to use S31600 because of the fluctuating pH and the presence of hydrogen sulphide. Moreover the screens need to be robust, with a design life of about twenty-five years."

The key factor in winning the contract for the Nan Shan plant was the fine-screening concept, combined with superior separation efficiencies and life cycle cost savings as a result of using S31600.

MORE INFO: www.nickelmagazine.org/0203/7.htm

Only Stainless Will Do

Corrosion-resistant nickel stainless steels help improve the service life of waste water treatment plants



Health concerns have made the treatment of potable water and waste water a primary environmental issue worldwide. As a result, many municipalities and local industries have turned to environmental technology companies to develop products to improve water quality.

One such company is Florida, U.S.A.-based Parkson Corporation, which provides a range of cleanwater services and manufactures complete treatment systems and individual components. Many of the components are manufactured entirely from nickel-containing stainless steel.

One of the more innovative products manufactured by Parkson is the Z Complete SuperScraper system. The SuperScraper line of products was developed in 1973 by Waterlink, now a division of Parkson Corporation, and includes bottom scrapers, surface scrapers, sludge removers, scum pipes and various accessories. These products, manufactured entirely from S30400 or S31600 stainless steel, have long service lives and, according to Parkson, many of the early installations are still in use today.

The Z Complete SuperScraper system is used in the primary sedimentation process, within rectangular sedimentation tanks measuring up to 80 by 11 metres. The primary sedimentation tanks are used in drinking water purification plants and in plants that treat municipal and industrial waste water. The system includes a bottom scraper, a surface scraper and a rotating scum pipe. Nickel-containing stainless steel is used because of its strength and reliability, as well as its resistance to corrosion and wear, all of which reduce maintenance costs by ensuring that the components last a long time.

More info: www.nickelmagazine.org/0203/7b.htm

CONTRA-SHEAR SEPARATION TECHNOLOGIES LTD. PARKSON CORPORATION

SUPER Jumbos

Molds made using K93600 alloy will help form almost 40 tonnes of composite parts on the new Airbus A380 super jumbo

Since the mid-1980s, the aerospace industry, especially defense, has made increasing use of fibre-and-resin composite parts in aircraft construction. In a high-profile passenger aircraft application, Europe's aircraft manufacturer Airbus will use some 40 tonnes of composite parts to reduce the weight and operating costs of its new 150-tonne, twin-deck, 555-passenger A380 super jumbo, due to enter service in 2006.

Since the resins are cured by heating to about 177° C, the composite parts are typically made on, or in, molds constructed of an alloy that matches the coefficient of thermal expansion of the cured composite material. Otherwise, the heated mold would warp and ruin the part, or, in the case of an injection-mold, expand and then crush the part as it cools.

The material that best fits the bill is K93600, an iron alloy with 36 per cent nickel. Charles-Edouard Guillaume invented Invar ™, as it is best known, in 1896, and an alloy with more suitable properties has yet to be developed.

"Invar 36 is used in aerospace because there is no other material as durable and that has the [right] coefficient of thermal expansion," says Jerry Anthony, president of mold and tooling manufacturer UCAR, in Irvine, California, U.S.A. "It has nothing to do with price. Invar stands alone."

Airbus contracted UCAR to design and build seven layup molds for the outer skin of the A380 wingboxes, situated where the main wings attach to the fuselage. In addition, UCAR has built two resin transfer molds, which will be used to make I-beam stiffeners inside the wingboxes. And the company is in the process of building a third.

The average size of the seven molds is 3.2 by 7.4 by 0.8 metres. They weigh an average of 12.2 tonnes apiece and add up to nearly 86.5 tonnes of K93600. UCAR utilized K93600 and weld wire manufactured by Special Metals of Huntington, West Virginia, U.S.A. In 1993, K93600 tool making represented five per cent of UCAR's business; today it represents 60 per cent. As manufacturers design larger aircraft and struggle to wring more fuel efficiency out of their

A WELDER pieces together the 'egg crate' base that will support the mold surface for the outer skin of the Airbus A380 wingboxes.

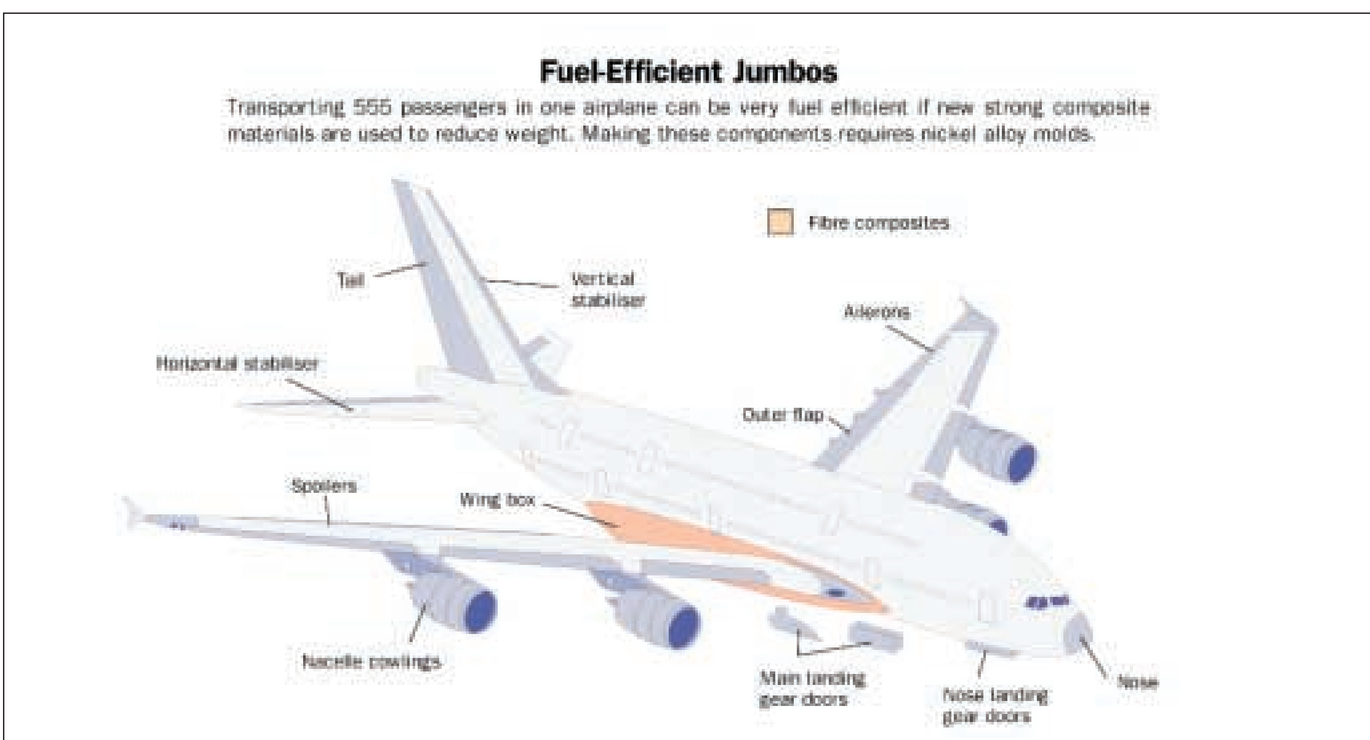
creations, they will use even more composite parts. "Weight for weight, composites are much stronger than aluminum," says Anthony. "The composite parts can be made thinner and more complex than aluminum pieces." Single-piece composite parts can also replace assemblies traditionally made of many pieces of aluminum that are bolted and riveted together, thus achieving important cost savings.

To build a lay-up mold, UCAR begins by constructing a support structure for the mold surface on which the composite part will be laid up. Called an egg crate base, the support structure is made from pieces of 6.35-millimeter-thick plate oriented vertically and welded to each other to form the mold structure (see acompanying photo). The upper edges of the egg crate base are cut to a 25.4-millimetre offset of the finished surface of the mold. Then 25.4-millimetre-thick face sheet is bump formed on a break press to form the rough shape of the finished surface and then GMAW (MIG) welded to the upper edges of the egg crate base. The face sheet surface is then machined with a 5- or 6-axis milling machine to a contour tolerance of plus or minus 0.19 millimetres, the thickness of five human hairs. It is then polished to form the mold surface.

The A380 will use composite parts in the nose and main landing gear doors, engine nacelles, spoilers, flaps, the central torsion box and much of the tail, including the vertical and horizontal stabilizers. If ongoing research in Europe is successful, the use of composites in the aircraft of the future will increase.

By Carroll McCormick, a Montreal-based freelance writer.

MORE INFO: www.nickelmagazine.org/0203/8.htm



AIRBUS INDUSTRIES UCAR

Ultra-Light **Stainless**

A stainless steel 'sandwich' material, developed by Volvo, promises lighter, safer and environmentally sound cars, trucks, trains, aircraft and boats. *By Dean Jobb*

Cars built with HSSA components could end up weighing 50 to 70 per cent less than conventional vehicles, Volvo predicts.

Roland Gustafsson sees himself behind the wheel of a sleek red Volvo, seated under a gleaming stainless steel hardtop that weighs a mere 8.5 kilograms. There would be a lot more to this car than good looks—it would be safer, burn less gasoline and, when the car ended its days on the scrap heap, the shiny canopy would be 100 per cent recyclable.

Thanks to a composite material the Swedish scientist has invented, such cars—as well as buses, trucks, trains, aircraft and even ships containing ultra-lightweight stainless steel components—could soon be a reality. Gustafsson, project manager with Volvo Technology Centre's concept centre in Gothenburg, Sweden has developed and patented a promising new material that is a hybrid stainless steel assembly (HSSA) using nickel stainless steel. HSSAs are "sandwich" structures consisting of two sheets of thin stainless steel bonded to a core of miniature stainless steel fibres (see photo page 11).

The result is a material as thin and easily shaped as conventional sheet metal, lighter and stiffer than aluminum, and that offers built-in insulation against noise and vibration. The shiny hardtop on Gustafsson's dream car would be eight times stiffer than one formed from sheet aluminum and would tip the scales at one-quarter the weight of the same component fashioned from plastic composites.

"It's a construction material that is ultra-light and which has unique properties in strength, stiffness and ductility," Gustafsson notes. "It's hard to believe it is that formable. We can deep-draw it even better than solid steel."

Based on the material's superior performance during an initial round of tests, scientists in Britain and the United States have launched an intensive research program to investigate the properties and potential uses of HSSAs.

The idea of using a sandwich structure to strengthen materials is nothing new—think of the corrugated core that reinforces an ordinary cardboard box. "It's a common way of creating stiff panels, to make them like a sandwich," says Gustafsson. "What I did was 'micronize' the idea and bring it down to a level where you have a core of stainless steel fibres which are, in this case, eight to twenty microns in diameter."

The idea grew out of work being conducted for Volvo's automobile division a half-dozen years ago. "We were looking for lightweight design in all different types of materials, and typically in those days it was very much about aluminum. I figured out that it could be interesting to try to use the structure to create stiffness and low weight, instead of just light material in itself."

He settled on stainless steel for its durability and corrosion resistance, using 0.2-millimetre-thick sheets of S30400 for each of the faceplates (sheets of S31603 have also been used). Thin strands of drawn S31603 stainless—commercially available and used to make filters and electromagnetic shielding for computers—were cut into 1-millimetre lengths to create fibres for the core. At diameters of less than 20 microns, Gustafsson says, the fibres become an extremely good material.

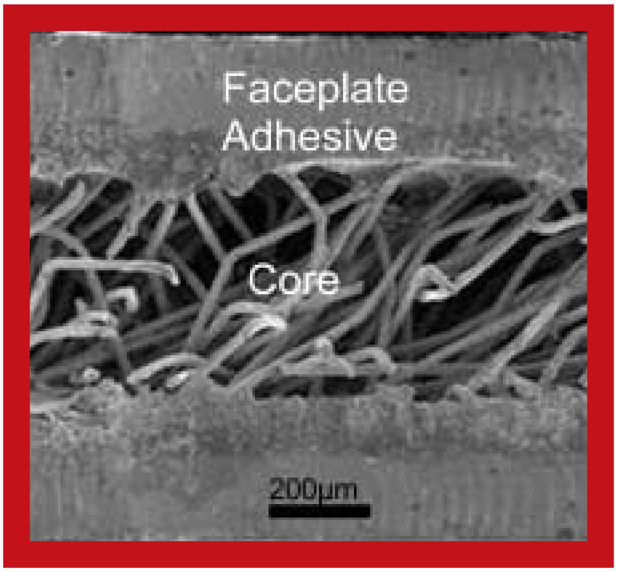
To attach the fibres, Gustafsson worked with a German textile manufacturer to modify a process, known as flocking, that is used to apply short fibres to cloth to create a velvety surface. The base plate is coated with a thin layer of epoxy, and an electromagnetic field is switched on to accelerate the stainless steel fibres on to the sheet metal, ensuring a firm bond and as much metal-to-metal contact as possible. The magnetized fibres repel one another, keeping them for the most part perpendicular to the base plate. Varying the current to alter the electromagnetic field makes it possible to control the surface density of the fibres. The second plate is then attached with epoxy, and the sandwich sheet is pressed and baked under pressure.

The prototype sheets have an overall thickness of 1.4 millimetres—comparable to the 1.2-mm-thick body aluminum used in the automotive industry—but fibre thickness, length, angle and density can be varied to produce other forms of HSSAs, each with unique properties. "You can scale up or scale down the core by using different types of fibres," says Gustafsson. "We don't know the borderlines yet for different applications, for different combinations."

To understand how best to build and utilize HSSAs, the Cambridge-MIT Institute (CMI)—a joint venture of Cambridge University and the Massachusetts Institute of Technology—is conducting a three-year research program funded by Volvo. Work at MIT will focus on energy absorption, crashworthiness and the impact of fatigue. Researchers at Cambridge will experiment with different core components and arrangements of fibres, as well as examining the structure, durability and weldability of the material.

"What our research project is all about is optimizing the core structure, so it will give you the best combination of properties," says William Clyne, professor of mechanics and materials at Cambridge. "It's a concept, really, and exactly what properties you get does depend quite a lot on exactly what the core structure is."

Other grades of stainless can be used for both faceplates and fibres. The Cambridge team is exploring the option of using fibres formed from a higher chromium stainless alloy such as S44600, to take advantage of its magnetic properties. The porous nature of the core—empty space between the fibres can account for between 80 and 95 per cent of its volume—demand the corrosion protection that stainless affords. "Simply painting the surface would obviously not eliminate the danger that moisture or fluids could get into the gap and cause it to corrode from the inside out," Clyne notes. Such permeability, however, may prove to be an asset, enabling sensors to be embedded or a cooling fluid to be circulated through the hollow core in applications where surface heat is a problem.



HSSA: Stainless steel fibres, less than 20 microns in diameter are seen here between two sheets of 0.2-millimetre-thick sheets of stainless steel.

Clyne's research into the welding properties of HSSAs will be particularly important. Preliminary tests conducted at Cambridge found it difficult to join the material using resistance welding techniques common in the automobile industry. "The HSSA adhesively-bonded material could not be successfully welded in these initial trials" and "weld flaws and faceplate damage occurred," states a paper published in February 2002.

Clyne, however, is optimistic the problems can be overcome. "It certainly can be welded," he says of the material, "but it does depend a lot on the core structure. What you need is a reasonably good conductant through the thickness (of the sheet), so the steel fibres have to be in reasonably good contact with the two faceplates."

The auto industry may hold the greatest potential for applying HSSAs, enabling car makers to design lighter, more fuel-efficient vehicles without compromising safety. Besides their obvious potential as a replacement for sheet metal in building fenders, hoods and roofs for cars, HSSAs can be formed into tubular members and used as structural components. The material crushes in an accordion-like fashion (a property Gustafsson says researchers have termed "sheer folding mechanism"), cushioning the impact of a collision.

Preliminary studies of the material's crashworthiness found it absorbed 50 to 60 per cent more energy than did solid sheet metal, says Professor Tomasz Wierzbicki, director of MIT's Impact and Crashworthiness Laboratory. "You can see the future fleet of cars made of this material, which, though they'll have the same weight, will be much stiffer and more crashworthy. Or you can say I'd like to maintain the stiffness and the crash performance, but I'd rather decrease the weight."

Cars built with HSSA components could end up weighing 50 to 70 per cent less than conventional vehicles, Gustafsson predicts. The material's hollow core makes it an excellent dampener, insulating against noise and vibration. He has used HSSAs to design a one-piece firewall for cars, shielding occupants from the heat and noise of the engine compartment without requiring a layer of thick rubber insulation.

The environmental benefits of HSSAs are extremely promising. Gustafsson has conducted a life-cycle assessment based on a material's environmental load—a measure of the resources used to create a product and any emissions it creates—for the hardtop of a car driven 200,000 kilometres over its lifetime. While a hardtop made of HSSAs has the highest environmental load at the manufacturing stage, fuel savings during use and recyclability make it more environmentally friendly than a hardtop built of steel, aluminum, or plastic composites.

Dean Jobb is a Halifax-based freelance writer.

MORE INFO: www.nickelmagazine.org/0203/11.htm

Tunnel Reopens

Nickel stainless steels are used to clad the tunnel walls and in a new fire suppression system

The Mont Blanc tunnel, near the French ski resort of Chamonix, is a major, 11.6-kilometre highway link between France and Italy. It was reopened to traffic in 2002 after three years of extensive work to repair damage caused by a fatal truck fire in March 1999.

To prevent a similar tragedy from occuring, safety standards have been upgraded significantly. One of the main objectives was to improve both the active and passive means of fighting vehicle fires within the confined space of the tunnel and, to that end, the Italian National Road Authority (ANAS), issued new directives for rehabilitation work. These included the specification that nickel stainless steels be used as the structural material in key safety improvements. Stainless steel was chosen because of its ability to resist both corrosion and heat.

Nickel stainless steels have been used to fabricate ventilation fans that operate even in the presence of smoke and high temperatures. They were also used in the lighting equipment and ceiling cladding, and in the piping and fittings of the fire-suppression systems.

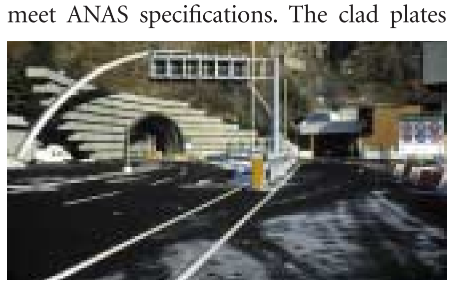
SAFETY IN THE MONT BLANC TUNNEL has been improved significantly through the use of heat- and corrosion-resistant S31603 stainless steel for several key design elements.

Stainless steel cladding was used to anchor fibre cement panels to the walls of the tunnel over an area totaling 20,000 square metres. The cladding, which is corrugated and consists of 0.5-millimetre-thick S31603 stainless steel sheet, fulfils the functions of waterproofing, drainage and fire resistance. Another important consideration was ease of fabrication in terms of simple rolling, forming and welding, and the material's resistance to corrosion means little maintenance will be required.

The walls along the full length of the Mont Blanc tunnel are clad with panels of fibre cement, and their finish and colour meet ANAS specifications. The clad plates are fastened to the tunnel wall with the aid of curved stainless steel strip and stainless steel anchor bolts.

The anchor bolts are fabricated from round bars, also of S31603. They were tested at high temperatures in accordance with ISO 834 specifications. The results proved that the anchoring system resists deformation for at least two hours at temperatures up to 1,000° C. At higher temperatures failure results from the thermal deterioration of the rock, rather than from a failure of the anchors. The corrosion resistance of stainless steel is also important for another reason: since the formation of iron oxides is eliminated, there is no increase in volume and therefore no loss in anchoring efficiency.

The tunnel's new fire supression system has been designed to guarantee safety, reliability and efficiency. During the winter months, large volumes of ground water result in high hydraulic pressures in the pipes that carry the water. S31603 stainless steel is sufficiently strong to withstand these pressures. Three different diameters of pipes are used: 219.1, 168.3 and 114.3 millimetres. They are joined by GTAW (TIG) or laser welding and assembled with the use of slip-on flanges.



STAINLESS STEEL CLADDING (above)has been used to anchor fibre cement panels to the walls of the tunnel and rock bolts (right), made from round bars of S31603 stainless steel, anchor the stainless steel shapes to the tunnel walls.

Adapted, with permission, from the June 2002, No. 148 edition of "Inossidabile" *published by Centro Inox, the Italian Stainless Steel Development Association.*

MORE INFO: www.nickelmagazine.org/0203/12.htm



WATER from Lake Como is pumped underground through S30400 stainless steel pipes, 700 millimetres in diameter (above). The use of corrosion-resistant nickel stainless steel should result in lower maintenance. Drinkable water is pumped to a storage tank through stainless steel pipe, 400 millimetres in diameter.

Italy's Underground Water Plant

Nickel stainless steel ensures corrosion resistance and low maintenance of high-capacity plant

For about 20 years the citizens of Como, Italy, have drawn water from their lake as an alternative source of drinking water. When demand for water increased, the municipal company ACSM decided to build a high-capacity drinking water plant rated at 33,000 cubic metres per day.

What's unusual about the plant is that it's in an underground cavern in Bardello Mountain, which dominates the town. The plant takes water from Lake Como and brings it up to drinkable standards through the addition of ozone and chlorine dioxide, and in a large-enough quantity to meet the increased demand.

The 20-million-Euro plant began operation in January 2001, and Lake Como has since become the only source of drinking water for the entire town. ACSM says the citizens have accepted the change and are satisfied with the quality of the water.

The plant was constructed inside Bardello Mountain for two reasons: first, it is hidden from view, which is important for a town that attracts a high number of tourists, and second, it does not occupy valuable urban real estate.

The climate inside the cavern is very humid. Metal surfaces easily reach the air dew point and become wetted by condensation, thus rendering them susceptible to corrosion. It was in order to prevent this that ACSM selected nickel-containing stainless steel for piping, flanges, fittings and nuts and bolts. Pipe diameters range from 400 to 700 millimetres and wall thickness from 3 to 4 millimetres. A total of 958 metres of pipe were used.

Como, Italy, 30 kilometres north of Milano, where a 33,000-cubic-metre-per-day drinking water plant has been constructed in a cavern inside of Bardello Mountain.

CENTRO INOX

The inside faces of these components resist corrosion in all stages of the water treatment process, leaving the quality of the water unaffected, while the outside faces are likewise resistant, even though they are constantly wet.

The use of nickel stainless has enabled ACSM to minimize maintenance costs and avoid interruptions to the plant's operation. Two varieties, S30400 and S31600, were used, 49 tonnes of the later in the ozone section of the treatment plant.

Adapted, with permission, from the December 2002, No. 150 edition of "Inossidabile" *published by Centro Inox, the Italian Stainless Steel Development Association.*

MORE INFO: www.nickelmagazine.org/0203/13.htm

THE AUSTRALIAN NICKEL INDUSTRY NETWORK (AusNiNet) launched a web site in January 2003. Provided are web site and e-mail links for all 12 members of the network and an explanation of what the network does and how to join. www.ausninet.org

Scaling and Corrosion

The scaling of surfaces by low solubility salts such as calcium carbonate or struvite, biofouling of water distribution pipes, and the corrosion of metals by aggressive waters or sea water ingression are just a few examples of the problems faced by the water and process industries.

To address these challenges, The International Water Association (IWA) and The School of Water Sciences, Cranfield University, is organizing a conference on scaling and corrosion in water to be held at Cranfield University in Cranfield, U.K. on March 25-27, 2003. Common process problems found in domestic, commercial and industrial applications where water or waste waters are in contact with materials will be examined.

This conference will promote the exchange of the latest information on scale and corrosion problems, their prediction, testing and control.

The conference will also provide a good opportunity for scientists, researchers and professionals in this area to network with each other and discuss key issues. NiDI consultant Carol Powell will speak on “Stainless Steels in Water and Waste Water Systems.”

Please contact: Conference Secretary, School of Water Sciences, Cranfield University, Cranfield, MK43 OAL U.K. Tel: +44 1234 754902; Fax: +44 1234 751671; E-mail: iwa@cranfield.ac.uk; Web site: www.cranfield.ac.uk/sims/water/iwa

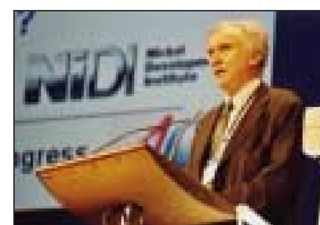
90 Years Young

This year marks the 90th anniversary of the discovery of stainless steel by Sheffield, U.K., metallurgist, Harry Brearley. It also coincides with a series of initiatives in the South Yorkshire region designed to enhance the reputation of this region of the U.K. as a centre for excellence in advanced metals, including stainless and special steels.

The British Stainless Steel Association (BSSA), therefore, will hold a two-day conference on April 3-4, 2003 entitled “Stainless Solutions for a Sustainable Future.” The conference will be held at the Magna Science Adventure Park in Rotherham, South Yorkshire, U.K.

During the first day of the conference, speakers will address the theme of sustainability from a number of different perspectives, covering key issues relating to energy, human and environmental health, materials and sustainable policy in action.

Speakers will review the impact of the latest thinking and legislation in these areas and to illustrate applications where stainless steel provides a practical material solution towards the development of a sustainable future.



DR. IVOR KIRMAN, President of NiDI

Dr. Ivor Kirman, President of NiDI, will speak on the topic of “Ensuring Future Market Access for Stainless Steel.”

The second day of the programme offers optional visits to the area’s leading R&D facility (Castings Technology International) or one of it’s newest attractions (the Millennium Galleries & Winter Gardens). These tours will be followed by an opportunity to visit the U.K.’s largest stainless steel works (AvestaPolarit).

The conference will be hosted by Ossi Virolainen, President and CEO of AvestaPolarit.

Please contact: Alison Murphy, British Stainless Steel Association, Broomgrove, 59 Clarkehouse Road, Sheffield S10 2LE, United Kingdom. Tel: +44 114 267 1260; Fax: +44 114 266 1252; E-mail: enquiry@bssa.org.uk; Web site: www.bssa.org.uk

UNS details

Details of the chemical compositions (in percent by weight) of the 7 nickel-containing alloys and stainless steels mentioned in this issue of *Nickel*.

Alloy	C	Cr	Fe	Mn	Mo	N	Ni	P	S	Si
K93600 (Invar) P.8	-	-	64	-	-	-	36	-	-	-
S21800 P.5	0.10 max	16.00-18.00	-	7.00-9.00	-	0.08-0.18	8.00-9.00	0.04 max	0.030 max	3.50-4.50
S30400 P.5, 6, 7, 10, 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.4, 7, 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
S31603 P.10, 12	0.030 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
S31653 P.5	0.030 max	16.00-18.00	-	2.00 max	2.00-3.00	0.10-0.16	10.00-14.00	0.045 max	0.030 max	1.00 max
S32205 P.5	0.030 max	22.00-23.00	-	2.00 max	3.00-3.50	0.14-0.20	4.50-6.50	0.045 max	0.030 max	1.00 max

PETER CUTLER/NiDI

MODEL AIRPLANE PHOTO

S30400 Model Airplane

This toy model airplane (and four other models: a light truck, biplane, helicopter, and jeep) are being marketed by a Japanese company, Yoshu Corp. The challenge is to piece together forty irregularly cut pieces of S30400 stainless steel plate without instructions. No adhesives are required. Instead, the puzzle is held together by inserting a final pin. Since the parts are not bonded together, a chattering sound is produced when the pieces are handled. The Japanese expression for this sound is "kacha kacha," hence the name of the product is "Kacha-Pin." For more information see their website: www.yoshu.jp or e-mail: nabihei@yoshu.jp

NiDI e-learning Tools

NiDI has launched the first in a series of e-learning modules designed specifically for architects. These are interactive learning tools that are downloadable from the NiDI web site in Portable Document Format (PDF) so that you can view them off-line at your leisure.

The first module, is entitled "Forms of Stainless Steel Corrosion." It was written by NiDI consultant Catherine Houska and edited by NiDI Technical Director Gary Coates.

"Forms of Stainless Steel Corrosion" is seven pages in length and looks briefly at the various forms of corrosion (tarnishing, pitting, crevice corrosion and galvanic corrosion). These can all be avoided in architectural applications by correctly selecting, installing and maintaining stainless steel.

To download this PDF, go to:
http://www.stainlessarchitecture.org/index.cfm/ci_id/11044.htm

@www.nidi.org

NiDI has posted three new learning tools online:

- **WATER:** *'Crevice Corrosion Engineering Guide'* is a downloadable program that predicts how seven different nickel-containing materials will perform under the water conditions that you specify.
  http://www.nidi.org/index.cfm/ci_id/10646.htm
- **CHEMICAL PROCESSES:** *'The Basics of Corrosion'* is a 20-minute online slide presentation with audio, designed for chemical process engineers.
  http://www.stainlessarchitecture.org/index.cfm/ci_id/10821.htm
- **ARCHITECTURE:** *'Forms of Stainless Steel Corrosion'* is a downloadable PDF file with interactive animations and a self-test quiz designed for architects.
  http://www.stainlessarchitecture.org/index.cfm/ci_id/11044.htm

COMING EVENTS

Corrosion

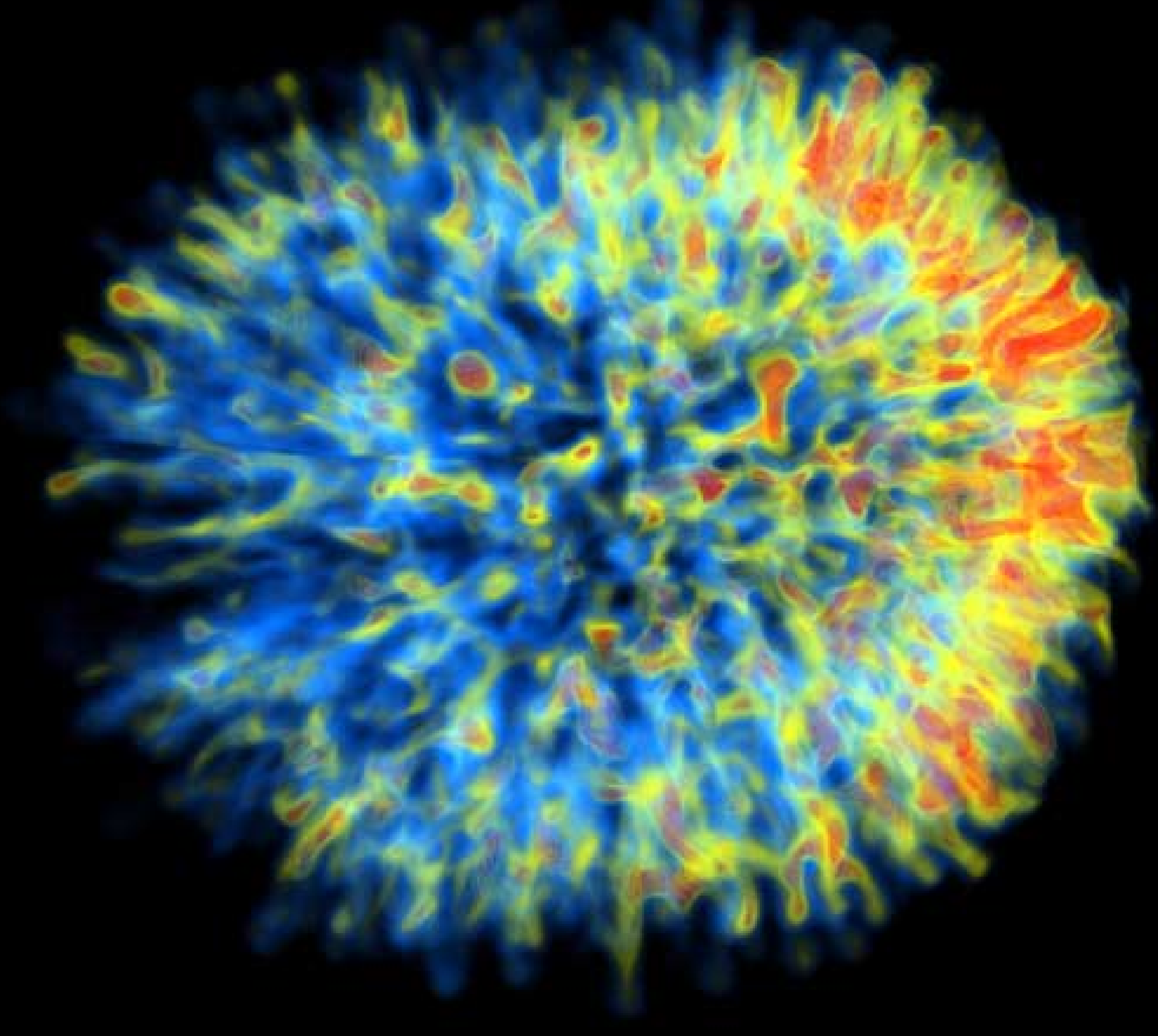
NACE INTERNATIONAL The 58th Annual Conference & Exposition, the largest and most recognized event dedicated to solving corrosion problems in every industry, will be held at the San Diego Convention Centre, March 16-20, 2003. Features include: technical committee meetings, technical symposia, courses, tutorials, seminars, field trips, special lectures, and more than 300 exhibitors. Please visit NiDI at booth 1212. Contact: Corrosion 2003 c/o ExpoExchange, P.O. Box 3867 Frederick, MD, 3867, U.S.A. Tel: +1 301 694 5243; Fax: +1 301 694 5124l; E-mail: cor031.attendee@expoexchange.com; Website www.nace.org

3RD CHINA INTERNATIONAL STAINLESS STEEL CONGRESS 2003 The China Iron and Steel Association (CISA), Stainless Steel Council of the China Special Steel Enterprises Association, and the Metallurgical Council of the China Council for Promotion of International Trade, are hosting this congress, in conjunction with the 3rd International Stainless Steel Exposition (STEXPO), May 13-15, 2003 in Shanghai, China. Special emphasis will be placed on market development for stainless steel in China. Please contact: International Cooperation & Consulting Dept., Metallurgical Council - CCPIT, No. 46, Dongsixidajie, Beijing, P.R. China, Tel: +86 10 65220754; Fax: +86 10 65254154; E-mail: mcinco@metallurgy-china.com; Web site: www.metallurgy-china.com

NICKEL/COBALT CONFERENCE 2003 This conference will be held at the Rendezvous Observation City Hotel on Scarborough Beach, Perth, Western Australia, May 19-21, 2003. It will feature papers by leading international experts. Topics include: Pressure acid leach treatment of nickel laterite ores; processing of sulphides by pressure acid leach, bioleach and other hydrometallurgical processes; plant design and operation reviews and issues; new and developing projects for laterites and sulphides; purification, separation and recovery by solvent extraction, ion extraction, electro-winning, precipitation, etc. Please contact: ALTA Metallurgical Services, P.O. Box 705, Castlemaine, Victoria 3450, Australia. Tel: +61 3 5472 4688; Fax: +61 3 5472 4588; E-mail: alta@alta.com.au; Web site: www.altamet.com.au

THE SEA HORSE INSTITUTE MARINE CORROSION CONFERENCE The Sea Horse Institute meeting provides an open forum through which practical information and solutions related to marine corrosion and biofouling can emerge. It will be held this year at Wrightsville Beach, North Carolina, U.S.A., August 10-14, 2003. Active participation is encouraged from all attendees who typically come from a broad range of disciplines and with varying levels of expertise. The format of the meeting is unique and very informal. Although there is an agenda, attendees are encouraged to bring examples (slide, view graphs, etc.) of marine corrosion problems and solutions for "show and tell" during the technical sessions. Input is encouraged. Please contact: Lisa Weiss, Conference Coordinator, Tel: + 1 910 256 2271 ext. 300; Fax: + 1 910 256 9816; E-mail: seahorse@laque.com; Web site: www.marine-corrosion.com

ORIN RUSSIE/ODOT PHOTO/VIDEO YOSHU CORP.



The Birth of Nickel

Nickel is the fifth most common element in the Earth. But where did all this nickel come from?

Billions of years ago, nickel was created in supernova explosions. This is the only place in nature where the temperature and pressure conditions were sufficient for the nickel atom to form.

This 'false' colour photo, compliments of the Lawrence Livermore National Laboratory, shows the concentrations of nickel isotopes being expelled from a star as it expands in just such a supernova event.

How interstellar nickel coalesced into solid objects and then into planets such as the Earth is the domain of cosmologists and astronomers. But however it happened, nickel has been an important part of the Earth since its beginning, well before life on earth began.

MORE INFO: www.nickelmagazine.org/0203/16.htm

LAWRENCE LIVERMORE NATIONAL LABORATORY