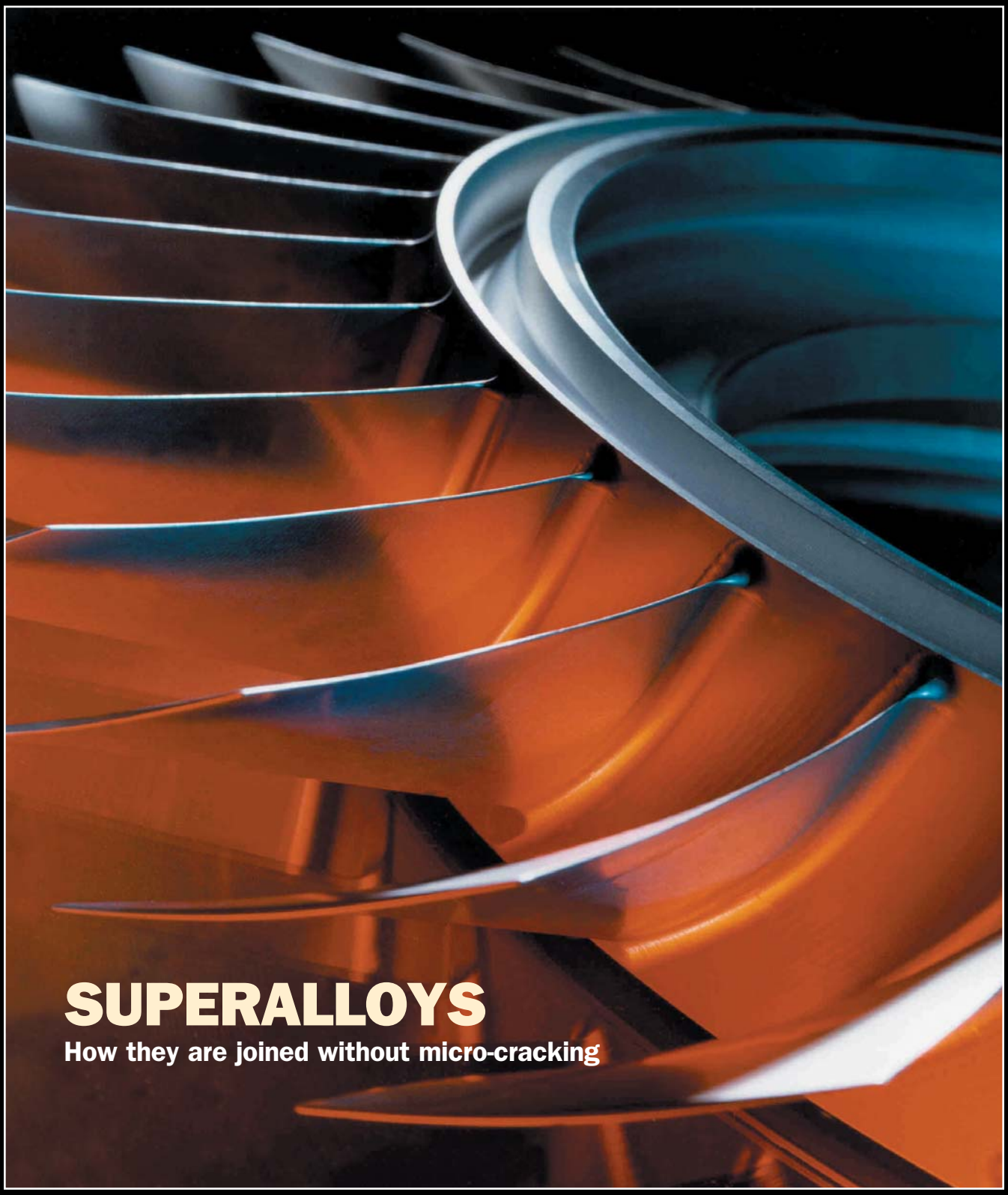
NICKEL

New uses for nano-nickel

Japan's solution to diesel exhaust

JULY 2004 VOLUME 19, NUMBER 3 THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS



SUPERALLOYS

How they are joined without micro-cracking

NICKEL

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The Magazine Devoted to Nickel and its Applications

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The Great Enabler

THE USE OF NICKEL AND NICKEL-CONTAINING STAINLESS STEELS AND ALLOYS continue to increase worldwide. Some applications are novel and others are commonplace. But even the old uses of nickel contribute to higher demand. That's because they are being applied in areas of the globe where they have not been used previously. Consider China, the largest developing economy in the world, where the use of nickel tripled in the five-year period from 1997 to 2002.

Demand for nickel in the developing areas of the world continues to grow strongly because governments are interested in infrastructure that is durable and long-lasting. Companies in the chemical, oil & gas, water treatment, food processing and other sectors are using modern, corrosion-resistant capital equipment in various parts of the developing world. And the people who live there are interested in hygienic, attractive cookware, tableware, portable electronics and household appliances – all of which contributes to greater demand for nickel.

Stainless steel is replacing cast iron in applications such as these wastewater treatment gates in the U.S.

WHIPPS INC.

Meanwhile, in the developed world, seemingly mundane but novel applications of nickel, such as the use of stainless steel for control gates in wastewater treatment facilities in the United States (see story, page 12), exemplify how stainless steel is replacing heavier materials that do not perform as well and cost more to maintain. This raises an important point about the increasing use of nickel: although the applications of nickel and nickel-containing materials are often site-specific, such as the wastewater treatment in the United States, they also have positive implications worldwide.

Reducing demand for electricity by making air conditioning more efficient (story, page 4) or lowering the amount of soot released into the air by diesel-fuelled cars or trucks (story, page 6) results in cleaner air for everyone. Similarly, improving the integrity of welds in a chemical processing vessel (story, page 8) lowers the risk of releasing toxic chemicals into the environment. Finding ways to join new superalloys together using non-traditional welding techniques promises to reduce the impact that air travel has on the natural environment (story, page 10). And using thousands of nickel-cadmium batteries in one central facility in an electrical grid reduces the likelihood of power outages, which can disrupt the daily lives of people in isolated communities (page 6). All of these applications of nickel and nickel alloys improve the lives of people in a specific area while also improving the global environment in which we all live.

Another benefit of nickel is that at the end of the useful life of a product, the metal is usually fully recycled. Therefore, the benefits to future generations of bringing more "new" nickel into play are not diminished. In certain areas, however, nickel is not being recycled to the degree that it could be, an example being nickel-plated plastics in products used in television sets, computers, kitchen appliances, and hundreds of other consumer goods. Fortunately, researchers in Japan have devised a technique that separates the plated nickel from the plastic at the end of the product's life without the use of chemicals (page 5). If this technique proves to be a commercial success, even this small amount of nickel can be reused by future generations.

Patrick Whiteway

Editor

inuse

THE LATEST NICKEL APPLICATIONS WORLDWIDE

A Cool Solution

Stainless steel heat exchangers key to energy-efficient air conditioners

Austenitic stainless steel is playing a central role in an effort to replace conventional air conditioning in downtown office buildings. New "greener" systems use lake water as a cooling medium and therefore only 25% of the electricity that would normally be needed by conventional air conditioners.

Toronto's lake-water cooling project, the largest of its kind in the world, takes icy water from a depth of about 83 metres in Lake Ontario and circulates it through office buildings via a network of underground pipes. The chilly water is used in customers' cooling systems through heat exchangers provided by APV Solutions & Services, a division of London-based Invensys.

LOCATED ON LAKE ONTARIO, the city of Toronto is taking advantage of cold lake water to reduce the cost of cooling office buildings during the summer months.

Under a C$4-million dollar contract with Enwave District Energy Ltd., APV is supplying 36 heat exchangers made of S31600 stainless steel to the project.

Enwave, one of North America's largest district energy providers, selected APV's Paraflow plate heat exchangers for the task. They provide a 93% recuperation rate (meaning only 7% of the chill is left behind in the water, an excellent recovery) while complying with the National Sanitation Association's requirements for potable water systems, says Osama Shenouda, process engineer for APV.

PARALLEL FLOW heat exchangers, made of S31600 nickel-containing stainless steel, make office air conditioners more efficient.

The Paraflow units (so-called because the flow regimes on either side of the plates are parallel to one another) are designed to operate in challenging chemical and industrial environments. They come is a variety of materials and styles depending on the application and the harshness of the process fluids. Typical application environments include steel plants, bauxite to alumina operations and coke oven plants. S31600 can be fully recycled at the end of the 40-to-50-year expected operating life of the units.

According to Enwave, more than half of Toronto's annual cooling load goes to counteract the heat produced by people, lights, and equipment in office buildings all year long. But the city is in a unique position to replace conventional, energy-guzzling air conditioning with deep-water cooling because its cluster of downtown towers sit beside a large, deep body of water.

The C$165-million project, which carries water at 4°C through 5-kilometre-long intake pipes to an onshore pumping station, will eventually produce enough cooling to service more than 1.8 million square metres of office space, the equivalent of about 100 towers.

Once the water has relinquished its chill, it will continue on its way to become part of Toronto's municipal water distribution system supply.

"This will be the largest lake water cooling service in the world, and the first of its kind in Canada," says Dennis Fotinos, president and CEO of Enwave. "It will meet up to 40% of the air-conditioning requirements for Toronto's downtown core, use up to 75% less energy than conventional electric chillers and eliminate forty-thousand tonnes of carbon dioxide and lower levels of pollution."

Few district energy systems have taken advantage of this abundant and renewable source of air conditioning. In 2002, Cornell University in New York replaced central campus chillers with a new source based on the cold deep waters of nearby Cayuga Lake – an initiative which earned it a Technology Award from the American Society of Heating, Refrigerating and Air-Conditioning Engineers. The other deep-water cooling systems are found in Stockholm, where salty water from the Baltic Sea passes through titanium plate heat exchangers, Halifax, Nova Scotia, Canada, where ocean water cools two commercial buildings along the waterfront, and the National Energy Lab at Keahole Point in Hawaii, U.S.A.

MORE INFO: www.nickelmagazine.org/0704/4.htm

APV SOLUTIONS & SERVICES / TORONTO TOURISM

More photos and text are available at the URLs given at the end of each article.

Recycling Nickel Plated on Plastic

New plasma technology developed in Japan allows recycling of metal-plated plastic

Metal plated on plastics poses problems at end-of-life. The metal is lost when the plastic is incinerated, down-cycled or landfilled. A new technique for stripping metal from plastic may encourage recycling of home appliances and automotive parts that currently end up in the waste dump.

Matsushita Electric Industrial, the largest electronics manufacturer in Japan and best known for its Panasonic brand name, recently developed technology for separating metal film from plastic without the use of chemicals. The process, which preserves both the metal and the plastic so that they can be remanufactured into new parts, was developed in collaboration with researchers at Kumamoto University in Japan.

Nickel is one of the most common metals used for plating plastics because it adheres well, can be easily cleaned and has good resistance to both corrosion and abrasion. Nickel-chromium plated plastics appear in several products, from decorative trim on small trucks and sport utility vehicles to fittings in showers.

Using an instantaneous electric discharge, the Matsushita technique physically separates the metal and plastic components in metal-plated plastics, including those coated with nickel. A spokesman for the company says the technology is economical and environmentally safe because it uses simple, inexpensive machinery and is energy-efficient and chemical-free.

Currently, nearly all metal-plated plastics are disposed of, rather than recycled. Although there are several methods to separate the two substances, including dissolving the plating with acid, none of them have caught on with manufacturers looking for end-of-life recycling solutions for their products.

But in Japan, a new law introduced in April 2001 specifies that home appliances, including television sets, air-conditioners, washing machines, refrigerators and, more recently, computers, must be 50-60% recyclable. The Matsushita technique will help Japanese companies adhere to the law because 99% of the recovered metals and plastics can be recycled using the new process.

Matsushita developed the technique for television cabinets, but it can also be used for casings of computers, projectors, game consoles and slot machines and on automobile parts. The company estimates it will use the technique on about 200 tonnes of car parts in 2006, the year it plans to begin producing the plating-removal machinery, and on 750 tonnes of TVs by 2010.

BY 2010, MATSUSHITA of Japan plans to begin removing for recycling the metal which has been plated on plastic components in TV sets.

But Matsushita says a few bugs still need to be worked out, namely a low separating capacity. Currently, the machinery can only process about 15 kilograms per hour. If this rate can be improved, the potential market both within and outside Japan is huge.

Development of the de-laminating technology began in November 2002, when Matsushita came up with the concept of using plasma discharge to separate metal film and plastic. The company approached Prof. Akiyama at Kumamoto University, a specialist in plasma discharge, for co-development, allowing the concept to blossom into application.

MORE INFO: www.nickelmagazine.org/0704/5a.htm

Quality and Cleanliness

Tsukiji Market in Tokyo is chaotic, crowded, noisy, wet and redolent of the ocean. In 2003, an estimated 615,000 tonnes of 450 different kinds of things that swim, float, crawl or cling to things in the sea were marketed here.

Tsukiji, also known as the Tokyo Central Wholesale Market, starts receiving fresh and frozen seafood late at night. At 3 a.m., the stage is prepared for the auction that starts at 5:30. After that, it becomes a busy retail market until early in the afternoon, when the whole market is hosed down in preparation for another cycle.

OPEN-TOP freezer chests in Toyko's Tsukiji Market are made of S30400 stainless steel.

PANASONIC

But when a product such as albacore tuna needs to be protected and preserved, it goes into giant, open-top freezer chests. The body of the chest and the slats upon which the tuna rest are made of S30400 stainless steel, as are the pans containing shellfish and other products that need to be kept alive for one or more days.

The Tsukiji market uses nickel-containing stainless steel for what it does best: providing hygienic, durable, easy-to-clean surfaces for a nation famous for valuing quality and cleanliness.

MORE INFO: www.nickelmagazine.org/0704/5b.htm

Chopping Harmful Diesel Emissions

An award-winning design reduces diesel exhaust emissions by 85%

When a citizens' group in Amagasaki, western Japan, successfully sued its local council, the impact was felt in the nation's capital, Tokyo. The lawsuit claimed the city had failed to protect Amagasaki residents from the diesel fumes spewing from trucks using a highway that ran by their homes, prompting leaders of the eight cities and prefectures that make up the sprawling Tokyo metropolitan area to introduce strict controls on diesel exhaust emissions.

For A'PEX ADS Company, a Japanese manufacturer of high-performance parts for racing cars and other vehicles, the challenge was to design a lightweight component that could filter out the smoke and soot from diesel-powered trucks, buses and cars. The result is the A'PEX DPF (diesel particulate filter) system, a compact unit not much larger than a conventional muffler, consisting of a stainless steel frame and casing, and silicon-carbide fibre filters that collect and burn uncombusted materials. The design won A'PEX a Japan Stainless Steel Association prize in the best product category in April 2004.

THIS COMPACT FILTER, made of S30403 and S30200 stainless steel, eliminates 95% of black smoke and 85% of the soot particles from diesel engine exhaust gases.

The system, which can be incorporated into the design of a new vehicle or fitted on those already in operation, is capable of eliminating 95% of the black smoke and 85% of the soot particles a diesel engine produces. The results hold for stop-and-go city driving, as well as high-speed highway travel, thanks to an on-board computer that monitors temperature, pressure and engine speed to ensure optimal combustion.

The unit collects sooty emissions in one of its filter chambers, and once it is full, the chamber is closed off and exhaust gases are directed into a parallel chamber. An electrical charge is used to burn off the collected soot; the cleaned chamber is refilled with exhaust while the next chamber is cleaned; and the cycle is repeated.

The tube-shaped DPF and the trio of cylindrical filter housings inside account for about 90% of each unit and are made of stainless steel. S30403 is used for the outer casing, and S30200 is used for internal components. The stainless steel is supplied by Nisshin Steel, one of the leading producers of stainless steel in Japan.

The DPF is produced in four sizes ranging in weight from 23 to 43 kilograms, with the largest built for 10-ton trucks and buses and the smaller ones designed to be fitted on four- and two-ton trucks. The 38-kilogram unit, designed for use on a large city bus, sells for about US$7,000.

A'PEX says each unit will have an operational life of eight to 10 years, with a filter replacement after five years or 250,000 kilometres of use. The unit was field tested on the bus fleet operated by the city of Yokohama, and as of the end of 2003, about 8,000 units were in use.

MORE INFO: www.nickelmagazine.org/0704/6a.htm

Another First for Nickel

Nickel has scored another first, this time in the world's most powerful battery energy storage system, or BESS, situated in Alaska, U.S.A. (and soon to be enshrined in the *Guinness Book of World Records*).

THIRTEEN THOUSAND nickel-cadmium batteries deliver sufficient power to prevent electrical outages in Alaska.

An estimated 90 tonnes of nickel are used as nickel oxyhydroxide (NiOOH) in 13,760 Saft nickel-cadmium batteries arrayed in an enormous (40-by-160-metre), single-storey building near the city of Fairbanks. To protect the batteries against the minus 50°C winters common to Alaska, the temperature in the building is maintained at 21° C year-round.

The US$30-million, turnkey BESS installation can deliver 27 Megawatts (MW) of power for 15 minutes, or 40 MW for seven minutes, thereby preventing or minimizing any power outages that might occur in the Alaskan grid. Between autumn 2003, when it started, and March 31, 2004, BESS delivered 15 discharges and saved an estimated 62,400 customer disconnections.

BESS was designed and built for the Golden Valley Electricity Association by a consortium consisting of Asea Brown Boveri (ABB) and Saft, the France-based battery manufacturer. ABB Switzerland supplied the DC/AC converter and controls, Saft Sweden, the nickel-cadmium batteries, and ABB U.S., the project management, construction, and ancillary systems.

In addition to benefiting Alaskans, the BESS system shows that such power storage installations can operate to the benefit of any community. They provide emergency power for the brief periods necessary to allow diesel or other auxiliary power-generating facilities to come on-line, thereby preventing outages.

That nickel plays an important role in this energy storage system indicates a significant potential new market for this enviro-metal.

MORE INFO: www.nickelmagazine.org/0704/6b.htm

GOLDEN VALLEY ELECTRICITY ASSOCIATION / A'PEX ADS

New uses for Nano-crystalline Nickel

Ultra-fine grain size key to new applications for nickel in the defense industry and in consumer sporting goods.

Thanks to ongoing developments in nano-technology research, nickel may one day compete with other materials in lightweight applications such as aerospace components, sporting goods and armour systems for defense.

A Canadian nano-technology company, Integran Technologies, has developed a relatively low-cost electro-forming process that can manufacture a variety of nano-crystalline forms, such as plates and strips, with a higher strength-to-weight ratio than some of the strongest lightweight alloys made of titanium and aluminum.

For example, the company's nickel-iron (50% nickel) armour plating is 2.5 times tougher than the required specifications for U.S. military vehicles, whereas its body armour is seven times stronger than that currently worn by soldiers and police. This increase in strength is accompanied by a decrease in weight.

Integran has partnered with the U.S. Department of Defense to design new products based on these properties.

On the consumer front, potential applications include lightweight helmets that use nano-metal foam technology, lightweight coatings to add stiffness to tennis rackets and golf clubs, and corrosion-resistant, durable edges for skates, skis and snowboards.

The key to the technology is a single-step process that produces nano-materials with a grain size a thousand times smaller than conventional alloys without sacrificing ductility. The tiny grain size makes the metal stronger and more resistant to wear.

Although first tested in the lab in the early 1980s, it was another decade before the technology found commercial applications.

The breakthrough occurred in the 1990s, when Ontario Hydro, a government-owned power company in Canada, was seeking an *in-situ* repair technology for the degraded tubes in its nuclear steam generator. Although nickel seemed like the ideal choice, because of its resistance to corrosion and stress corrosion cracking in nuclear reactors, its use was limited by poor mechanical strength.

POTENTIAL FUTURE USES of nano-crystalline nickel include corrosion-resistant, durable edges for sporting goods such as skates, skies and snowboards.

Nano-crystalline nickel saved the day, as it is four times stronger than conventional nickel while retaining all of the metal's other attributes. The resulting nano-crystalline "electro-sleeves" were fitted over the original tubes to provide resistance to pitting, denting, cracking and other forms of degradation. They remain intact today.

More recently, Integran has been working on bringing other applications to market. The versatility of the company's process allows for a wide range of product forms including powders, foams and complex net-shape components.

A RELATIVELY LOW-COST electroforming process has been developed to manufacture nano-crystalline nickel plates and strips.

INTEGRAN TECHNOLOGIES / PHOTOSPIN

"The electro-sleeve process remains one of the first-ever large-scale applications for nano-structured materials," says Gino Palumbo, Integran's president and CEO. "But we're still only scratching the surface in terms of applications for nano-nickel products. Our main limitation in promoting our technology in the nickel community has been in identifying the areas where our materials can best be of benefit."

Recent breakthroughs in nano-crystalline nickel have included its use in a nickel-iron coating with superior magnetic properties and as an environmentally benign substitute for nickel-beryllium alloys with better strength, resilience and electrical conductivity. Equally valuable are nano-structured analogs of nickel-iron alloys with low thermal expansion coefficient, such as those used in the shadow masks of televisions and computer monitors.

Palumbo also sees a future for nano-crystalline nickel-iron alloys in the manufacture of micro-electro-mechanical devices by electro-deposition. The current electro-deposits fall short on reliability because of their unpredictable properties. Electro-deposited bulk nano-structures promise to overcome this challenge by providing a uniform fine-grain structure throughout the device.

MORE INFO: www.nickelmagazine.org/0704/7.htm

The Battle Against Corrosion

Nine corrosion specialists recently presented their unique perspectives on the technical challenges facing the global chemical process industry. The venue was a conference in New Orleans, Louisiana, U.S.A. where about 200 chemical process engineers from around the world attended a session titled "*Process Industry Corrosion in the New Millennium.*" It was part of the annual conference of NACE International, the largest gathering of corrosion specialists in the world. The following highlights from the session show how nickel-containing materials are playing a leading role in the chemical process industry.

It is interesting to follow the developments of new alloys as they go through the various stages of development from a laboratory idea to full commercialization and four such nickel based alloys were described in New Orleans.

High temperature chloride-containing phosphoric acid, especially when containing abrasive solids, is a very aggressive media, but one that is an integral part of phosphoric acid production from phosphate rock. Acid producers are constantly seeking alloys that will give them improved equipment life. Martin Caruso explained how Haynes International developed alloy N06035, a high chromium, high molybdenum nickel base alloy, for that purpose. Autoclave tests confirmed its suitability and there are now plant installations. The alloy might find applications in other acids too.

Larry Paul of Thyssen-Krupp VDM discussed a number of field test results for R20033. The alloy, with about 33% chromium, 33% nickel, 0.5% nitrogen, but only 1% molybdenum, was developed for highly oxidizing conditions, which occur with nitric acid and certain sulphuric acid applications. However, it has been successfully used for weld overlay of boiler tubes, a high temperature application, and one that was not originally considered when developed.

Another paper by Thyssen Krupp VDM, this one by Helen Alves, included a case study for the production of Vitamin C. It involves a cocktail of chemicals, and laboratory tests were required to help choose the most suitable alloy. Their tests showed that N06059, a nickel-chromium-molybdenum alloy in the upper end of the "C-type" alloys, was the most suitable. N06059 has now reached that stage of full commercialization.

Lee Pike and Dwaine Klarstrom of Haynes International described a new high-strength alloy called C-22HS™. It is comparable to N06022 in terms of corrosion resistance, but can be age-hardened to produce nearly double the yield strength.

MORE INFO:
www.nickelmagazine.0704/8.htm

NEW ALLOYS are usually developed for specific conditions such as these pulp-and-paper vessels. However, they can find other, unanticipated applications.

OY METSÄ-RAUMA AB / TIM PELLING/NICKEL INSTITUTE

High Standards vs Low Cost

Can large chemical process companies save money by stocking just one type of welding consumable rather than a whole range as required for specific corrosion requirements?

This is not a question that Josef Heinemann of UTP Schweissmaterial GmbH set out to answer. However, he did show that one nickel alloy (Alloy 59) gives the best corrosion test results in a series of tests when used to weld a wide variety of base materials.

In New Orleans, he reported the results of a series of ASTM corrosion tests he performed on two different C-type base metals that had been welded with Alloy C22 filler metals (N06022 and W86022) and Alloy 59 filler metals (N06059 and W86059). He concluded that Alloy 59 was the best weld metal for his particular combination of base materials. But he went one step further, saying "N06059 and W86059 can be applied for the welding of all the other base materials of the C-type and for higher alloyed austenitic stainless steels."

Clearly, choosing this particular weld filler material may give the best corrosion results, but whether or not it would result in cost savings if it were the only material used in a large company remains to be answered. Of course, each company would require new welding procedures to qualify this filler metal for use for the various combinations of base materials.

MORE INFO:
www.nickelmagazine.0704/9a.htm

CAN ONE ALLOY be used for all welding filler applications in a large company?

Weld Two Times Faster

The welding of nickel base alloys using the GMAW/MAG processes can be dramatically improved simply by using multi-component shielding gases rather than pure shielding gases, such as pure argon.

This conclusion emerged from work done recently by Linde AG.

Thomas Amman of Linde AG explained how the company designed and tested a multi-component shielding gas that results in a stable arc, produces excellent wetting characteristics, and permits welding at higher speeds.

The gas is commercially available in Europe and can be obtained on special order in the U.S. It consists of argon (as the base gas), 0.05% carbon dioxide for arc stabilization and 30% helium to provide a heating effect that also provides excellent wetting characteristics. It also contains 2% hydrogen to facilitate travel speeds as high as 50 centimetres per minute – double the speed that is possible when pure argon is used. Argon-helium gas mixtures are commonly used for production welding of nickel alloys, but this gas appears to be a further improvement.

The gas is not recommended for welding stainless steels.

A MULTI-COMPONENT shielding gas can double the speed of welding nickel alloys.

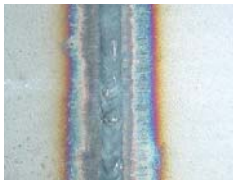
NICKEL INSTITUTE / SVEN-ERIK THUNBERG

MORE INFO:
www.nickelmagazine.0704/9b.htm

Still Not Sure About Heat Tint?

It is still not perfectly clear in the minds of most corrosion engineers whether or not heat tint, that slight discolouring of a metal around a weld where the metal has been affected by the heat of welding, negatively affects the corrosion resistance of stainless steels and nickel alloys.

There are simple, commonly available methods to remove the heat tint (immersion pickling, spray pickling and pickling paste, for example), but they use quite hazardous chemicals. But is it necessary to do so? Would a requirement to remove it be worth the cost? And how can you check if the passive layer has been disturbed?



DOES HEAT TINT change the corrosion resistance of a basemetal?

One corrosion engineer who is now convinced the removal of heat tint is a must is Rudolf Morach of Ciba Specialty Chemicals. He developed a simple pen-type electrochemical sensor that can measure the local reduction in corrosion resistance around a weld because of the heat tint. He used this sensor to conduct a large testing program on heat tint on welded pieces of stainless steels and nickel alloys.

His results were unequivocal: pickling gives a major improvement. The Nickel Institute has never argued that pickling of heat tint is always necessary, but that in many (but not all) corrosive services, it is advantageous. Thank you, Rudolf Morach.

MORE INFO:
www.nickelmagazine.0704/9c.htm

Unconventional Welding

Joining dissimilar superalloys requires inertia welding to avoid micro-cracking

If the aerospace industry is to reach its goals of reducing emissions and lessening its burden on the environment, the next generation of jet engines will need to burn fuel more efficiently and at higher temperatures. But building engine components capable of doing so poses a technological challenge: while nickel-based superalloys offer the heat resistance needed, they are difficult to join using conventional welding techniques.

Engineers at the University of Manchester and Rolls-Royce Plc, one of the world's largest manufacturers of gas turbines for aircraft, have teamed up to tackle this problem by applying inertia welding techniques to the production of compressor drums, turbine discs and shafts for jet engines. "Inertia welding has been around for some time," notes Prof. Philip Withers of the university's Materials Science Centre. "What's new is inertia welding as applied to aero-engines."

THIS INERTIA WELDER can join superalloy disc assemblies up to 600 millimetres in diameter. A large flywheel (right) provides the kinetic energy needed to make a solid-state joint.

ROLLS-ROYCE PIC

Inertia welding uses the heat generated by friction to fuse metal components together. A workpiece is spun at high speed on a flywheel and brought into contact with a stationary component. Within seconds, the pieces reach forging temperature at the point of contact and are bonded together without melting or the addition of liquid metal.

"Because of the large fly- wheel, you have a lot of stored kinetic energy," Withers explains, "and that kinetic energy will gradually dissipate as those surfaces rub. Heat is generated, which softens the metal, and you essentially hot-forge the two parts together." The speed of rotation and the pressure exerted as the pieces are brought into contact are strictly controlled to ensure a solid weld and that melting does not occur.

Withers' Manchester colleague, Dr. Michael Preuss, and Rolls-Royce metallurgist Gavin Baxter used inertia welding to join tube structures made of RR1000, a superalloy Rolls-Royce developed specifically for use in turbines. RR1000 consists of 50-60% nickel, 14-15% chromium,

14-19% cobalt, 4-5% molybdenum, 3% aluminum, and about 4% titanium. The powder-processed alloy resists cracking, corrosion and oxidation when subjected to extreme heat but is prone to micro-cracking as the metal solidifies after undergoing conventional welding.

The Manchester team studied the microstructure of the test welds and found that inertia welding produced better properties than fusion techniques using liquid metal. "You get an increased hardness in the weld zone," Withers reports. "It has the advantage that it also cleans out the surfaces so that you have a weld made from high quality metal." Post-weld heat-treating of the joint at a temperature of 50° C above the normal heat-treating temperature was found to reduce the residual stresses produced during welding.

The researchers also discovered that inertia welding can be used to join RR1000 to two other superalloys used in aerospace engines – N07001 and N07720, which can withstand temperatures of up to 870° C.

"They have different properties, and it is often difficult to join dissimilar metals while maintaining joint integrity," Withers notes. "With this joining technology, certain parts of the disc assembly may be made of one alloy and certain parts may be made of another."

Researchers are also exploring aerospace applications of linear friction welding, a related welding process in which components are rubbed together back and forth until enough heat is generated to join them. "That technology is being developed for blade-to-disc applications," says Withers. "You would essentially join a blade to a disc by a similar kind of weld, dispensing with the conventional dovetail joints used to attach turbine blades."

The research is part of a £4.7 million research program known as ADAM (for Advanced Aero-engine Materials), spear headed by Rolls-Royce, that brings together scientists at Manchester and five other British universities. The goal is to develop lightweight, high-temperature materials and new manufacturing techniques for aero-space applications. A demonstration engine may be completed as early as 2008.

Rolls-Royce is committed to cutting nitrous oxide emissions from engines used in civil aircraft by 50%. Also, by 2010, the company expects new engines to be using 10% less fuel than a comparable model produced in 1998. Inertia welding of nickel based engine components appears to hold one of the keys to reaching these lofty goals.

"Aerospace has to move towards improved emissions," notes Withers. "The way to do that is by being more efficient, and you get more efficient [and] you get a big environmental benefit if you can run your engine hotter."

MORE INFO: www.nickelmagazine.org/0704/10.htm

ROLLS-ROYCE is committed to reducing the amount of fuel consumed by its civil aircraft engines by 10% and cutting nitrous oxide emissions by 50% by 2010. Inertia welding is one of the keys to reaching these goals.

ROLLS-ROYCE PIC

SUPERALLOYS

Inertia welding has been used to join the following superalloys:

RR1000	– 55% nickel, 14.5% chromium, 16.5% cobalt and 4.5% molybdenum
N07001	– 58% nickel, 19.5% chromium, 13.5% cobalt and 4.3% molybdenum
N07720	– 57% nickel, 15% chromium, 16% cobalt and 3% molybdenum

Stainless Steel Water Gates

A total of 520 tonnes of stainless steel were used in a wastewater project in Alabama.

Modern wastewater treatment plants, designed to handle peak flows after rain storms, need sluice gates to control the movement of wastewater between storage basins. In a multi-billion dollar program to repair aging sewers and improve wastewater treatment capabilities in Alabama's Jefferson County in the United States, S30400, S31600 and S31603 stainless steel have become the material of choice for gates, replacing traditional cast iron and Ni-Resist.

STAINLESS STEEL is not yet the standard throughout the wastewater treatment industry, but it has taken at least 40% of the market.

Although fabricated stainless steel gates have been in use for only a short time, experience has quickly shown that they are less expensive, lighter, easier to install, and less prone to leaking. They also are more resistant to corrosion in the presence of hydrogen sulphide and require less maintenance.

"Cast iron gates have been in use in the collection system for 70 to 80 years," says Harry Chandler, assistant director, environmental services department for the Jefferson County Commission. "We started using Ni-Resist over twenty years ago. Price became an issue and we asked ourselves if we could get the stainless steel gates at lower cost than the Ni-Resist. It was only five to six years ago that we began to look seriously at alternatives."

The County's largest treatment plants are Village Creek and Valley Creek. Village has a nominal capacity of 550 million litres per day (LPD) and a peak capacity of 1,820 million LPD. Valley has a nominal capacity 840 million LPD and a peak capacity of 1,590 million LPD.

The two plants have at least 200 fabricated stainless steel gates, ranging in size from 1-by-1 to 4-by-4 metres. They were fabricated by several manufacturers, including Whipps Inc. of Athol, MA, U.S.A. and H. Fontaine Limited in Magog, Quebec, Canada.

Whipps fabricated 111 gates from 95-mm-thick S30400 plate for Valley Creek. They range from small 0.3-by-0.3-metre gates, weighing 200 kilograms (kg) to ones measuring 4.6 by 4.6 metres and weighing 7,300 kg each. The company also fabricated 29 gates from S31603 ranging in weight from 580 to 3,700 kg each.

"The choice of stainless steel depends on the corrosive conditions and whether they require a lot of welding," says Fred Perry, regional sales manager for the southeastern U.S. for Whipps.

Although Jefferson County has adopted stainless steel gates as the standard six to seven years ago, Whipps has been fabricating them since 1977. "We've made only 300 iron gates between 1977 and 2003, but over 6,000 stainless steel gates in that time period," Perry says. Stainless steel is not yet the standard throughout the wastewater treatment industry, but it has taken at least 40% of the market and is growing annually, according to Perry. The American Water Works Association (AWAA) recently published a standard, C-561, for stainless steel slide gates.

Fontaine, meanwhile, supplied 72 flange-

WHIPPS INC. AND H. FONTAINE LIMITED

back design gates, ranging in size from 1.22-by-1.22 metres to 3.05-by-3.05 metres, to the Village Creek treatment plant. The gates' weights range from 820 kg to 4,130 kg.

The stainless gates were fully assembled and tested before shipping to Jefferson County. Once on-site, they were bolted to thimbles, which had been set in the concrete basin walls during their construction. The thimbles were also fabricated from S31603 and range in weight from 420 kg to 885 kg.

The plate from which the gates are constructed, using a combination of bending and welding, range in thickness from 6.5 millimetres (mm) to 9.5 mm. Each gate is passivated before leaving the plant, and further passivated on-site.

Cast iron gates, on the other hand, require on-site final assembly and adjustments to make them fit well. Although the standard for stainless gates is the same as for cast iron, Fontaine reports that its gates leak at only half of the AWAA C560 recommended leakage rate. The less leakage at the gates, the less untreated wastewater is released from the facility into the environment.

Chandler cites other reasons for choosing stainless gates: "The Ni-Resist had become adequate for corrosion, but there are a couple of other issues. The cast gates are very heavy and slide up and down in a brass frame. If the gates are not used, they freeze up. We wanted gates that were not heavy and that were easy to move," Chandler explains. "The stainless steel gates don't corrode or bind and have a seal that lets them easily move up and down."

The problem with the cast iron gates is widespread, according to Chandler. "We have 4,800 kilometres of sewers and close to 100 control structures. In the past year and a half, we looked at them, and most of them we could not operate. The stainless steel gates operated and the cast iron gates did not.

"These things are going to operate for twenty to forty years. Because you can't turn them off, maintenance is a large issue. With cast, the wedges work against brass bushings that wear. Maintenance and replacement is more expensive.

"With stainless steel gates less maintenance is required on the electrical equipment

that raise and lower them. The seal on the stainless steel gate doesn't wear as much and is easier to replace than the cast seals.

"We have four treatment plants, and all have undergone expansion in the past six to seven years. We have installed stainless steel gates in all of them. Stainless steel gates are becoming the standard in our treatment plants."

The Village Creek peak flow treatment train became operational in June 2003. The part of the plant that will couple the treatment trains will be done in September 2004. Valley Creek will be completed in June 2005.

MORE INFO: www.nickelmagazine.org/0704/12.htm

THE MANY ADVANTAGES that stainless steel gates offer over cast iron and Ni-Resist gates include: lower cost, lighter weight, ease of installation and lower leakage rates. The gates pictured here range in size from 0.3 by 0.3 metres to 4.6 by 4.6 metres and weigh from 580 to 3,700 kilograms. Because they weigh less than cast iron gates, there is less wear and tear on the electrical equipment needed to raise and lower them.

WHIPPS INC. AND H. FONTAINE LIMITED

Nickel in China

SHANGHAI, the center of stainless architecture growth in China.

"If there are no serious setbacks with the Chinese economy or with the wider, global economy of which China is now a vital part, the pattern of nickel use in China will probably be very similar to that seen in other modern economies," says Dr. Ivor Kirman, president of the Nickel Institute.

Kirman made the comment in his paper "The Changing Pattern and Outlook for Nickel Use in China," which was presented at the China Nickel Outlook 2004 conference in Shanghai, China in May.

Total nickel use in China (primary nickel plus nickel in scarp and imported products) tripled in the five-year period from 1997 to 2002. Total use is estimated to have increased to 290,000 tonnes in 2002 from 86,000 tonnes in 1997.

However, there is a danger that price-driven substitution could have an adverse effect on the reputation of stainless steel for quality. Therefore, appropriate grade selection for particular applications is essential. Kirman said there are some areas in which compromises should not be allowed, such as the use of S30400 instead of S31600 in external marine environments or specifications for the thickness of chromium nickel plating.

"If substitutes are seen as lower-quality products, then the substitution will probably be reversed quickly," Kirman said.

MORE INFO: www.nickelmagazine.org/0704/14a.htm

Mint Masters

Very long service life, excellent recyclability, and high security against fraud have been and continue to be the main advantages of using nickel in coinage. However, allergic contact dermatitis emerged as a issue in the European Union when nickel was one of the materials selected for use in euro coins.

The nickel industry supports the action taken by governments to reduce the incidence of allergic contact dermatitis and believes the continuing use of nickel in coins is consistent with this goal.

This position was explained in detail by Dr. Ivor Kirman, president of the Nickel Institute, at the 23rd Mint Masters Conference in San Francisco, U.S.A. on March 23, 2004.

Dr. Kirman reviewed the process by which people can become sensitized to nickel (by direct and prolonged contact with the skin) and explained how subsequent exposure to nickel can elicit a response in already-sensitized individuals. The risks of elicitation created by jewelry were explained, and the EU regulations designed to reverse the trend of both sensitization and elicitation among the general population were reviewed. These regulations do not relate to euro coins, however, because coins are not intended to be in prolonged and continuous contact with the skin.

MORE INFO: www.nickelmagazine.org/0704/14b.htm

UNS details

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

Alloy	Al	B	C	Co	Cr	Cu	Fe	Mn	Mo	N	Ni	P	Pb	S	Si	Ti	V	W	Zr
F47006 (Ni-Resist D-2) P.12	-	-	2.4-3.0	-	1.7-2.4	0.50 max	-	0.8-1.6	-	-	18.0-22.0	0.25 max	0.003 max		2.0-3.2	-	-	-	-
RR1000 P.10	3	0.01-0.025	0.012-0.033	14-19	14-15	-	-	-	4-5	-	50 60	-	-	-	-	4	-	-	0.05-0.07
R20033 P.8	-	-	0.015 max	-	31.0-35.0	0.3-1.2	rem	2.0 max	0.5-2.0	0.35-0.6	30.0-33.0	0.02 max	-	0.01 max	0.5 max	-	-	-	-
S30200 P.6	-	-	0.15 max	-	17.00-19.00	-	-	2.00 max	-	-	8.0-10.0	0.045 max		0.030 max	1.00 max	-	-	-	-
S30400 P.5, 12	-	-	0.08 max	-	18.00-20.00	-	-	2.00 max	-	-	8.00-10.50	0.045 max		0.030 max	1.00 max	-	-	-	-
S30403 P.6	-	-	0.03 max	-	18.0-20.0	-	-	2.00 max	8.0-12.0	-	10.00-14.00	0.045 max		0.030 max	1.00 max	-	-	-	-
S31600 P.4, 12	-	-	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.12	-	-	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	-	-	-	-
N06022 P.9	-	-	0.015 max	2.5 max	20.0-22.5	-	2.0-6.0	0.50 max	12.5-14.5	-	rem	0.02 max	-	0.02 max	0.08 max	-	0.35 max	2.5-3.5	-
N06059 P.9	0.1-0.4	-	0.010 max	0.3 max	22.0 24.0	0.50 max	1.5 max	0.5 max	15.0-16.5	-	rem	0.015 max	-	0.010 max	0.10 max	-	-	-	-
N06035 P.9	-	-	-	-	33.0	-	-	-	8.0	-	rem	-	-	-	-	-	-	-	-
N07001 P.11	1.20-1.60	0.003-0.01	0.03-0.10	12.00-15.00	18.00-21.00	0.50 max	2.00 max	1.00 max	3.50-5.00	-	rem	0.030 max	-	0.030 max	0.75 max	2.75-3.25	-	-	0.02-0.12
N07720 P.11	2.0-3.0	0.02 max	0.03 max	14.0-16.0	15.0-17.0	-	-	-	2.5-3.5	-	rem	-	-	-	-	4.5-5.5	-	1.0-2.0	0.05 max
W86022 P.9	-	-	0.02 max	2.5 max	20.0-22.5	0.50 max	2.0-6.0	1.0 max	12.5-14.5	-	rem	0.03 max	-	0.015 max	0.2 max	-	0.35 max	2.5-3.5	-
W86059 P.9	-	-	0.02 max	-	22.0-24.0	-	1.5 max	1.0 max	15.0-16.5	-	rem	0.015 max	-	0.01 max	0.2 max	-	-	-	-

NICKEL INSTITUTE/TIM PELLING

A tribute to Paul Dillon (1921-2004)

Our friend and colleague C.P. (Paul) Dillon passed away on April 7, 2004. Paul was highly respected in the corrosion community and was a valued consultant to the Nickel Institute since its inception.

We remember Paul for his generosity of spirit and willingness to share technical knowledge and experience with others. He had strong opinions and held them with great conviction but was always ready to listen to those of his peers.

The Nickel Development Institute (NiDI) was formed in 1985, and we were fortunate to have Paul come on board right away as a consultant. He participated as a lecturer in NiDI's Materials Engineering Workshops, which were held in the U.S., Canada, and the U.K., until 1995, when poor health prevented him from travelling.

Paul continued providing the Nickel Institute technical service to enquirers to his last days. The Nickel Institute's high reputation for providing accurate and useful technical information is in large part due to Paul's knowledge and abilities.

Paul was the author of many books and technical articles published by NACE, MTI and NiDI. He was made an MTI Fellow in 2001 in recognition of his critical involvement in the formation of that organization. He was also a NACE Fellow, a certified NACE Corrosion Specialist, and taught the NACE Basic Corrosion Course for many years.

Paul's knowledge of chemistry, as well as corrosion, combined with his 34 years of service in materials engineering at Union Carbide, gave him some unique insights into how materials perform in a corrosive environment. He will be greatly missed in the corrosion community.

Preventing Plating Losses

Releases of nickel (to air, water and landfill) is a topic worthy of the attention of any manager of a nickel plating operation. The Nickel Institute has published practical advice in the form of some general process engineering suggestions that can help to prevent these losses.

U.K.-based consultant Bryan Fisher, who has 40 years of experience in the field, authored the paper "Avoid Nickel Plating Losses – Protect the Environment and Improve Profitability." The paper is Technical Series No. 10 089 in the Nickel Institute's series of papers and is available free of charge from our website.

Topics include: the nature of losses, losses in liquid form (dragout and carry over), action required to prevent losses, losses to the atmosphere (nickel salts as aerosol mist), and losses to landfill.

MORE INFO: www.nickelmagazine.org/0704/15.htm

PHOTOSPIN

COMING EVENTS

Air Pollution

An Air Pollution Control Symposium (AIRPOL) will be held Aug. 29, 2004 in Washington, D.C. Fifteen papers on various aspects of air pollution control will be presented at the event, which is co-sponsored by NACE International. Topics include materials selection for flue gas desulphurization systems, duplex and super duplex stainless steels in FGD service, and case studies at Syncrude Canada, Owensboro Municipal Utilities and Cinergy Gibson Unit #4. The chairman of the seminar is Nickel Institute consultant W. L. Mathay. Contact: www.nace.org/airpol

DSS CONFERENCE & EXPOSITION The American Water Works Association (AWWA) will hold its annual water distribution and plant operations conference, Sept. 26-29, 2004, in Chicago, Illinois, U.S.A. The new stainless steel marketing association SPLASH (an acronym for Stop Leaks, Ask for Stainless Help) will have a booth at the exposition. SPLASH Chairman, Stephen Lamb, will present a paper titled "Stainless Steel on the Rise in Water Distribution Systems." Contact: www.awwa.org/conferences/dss

STAINLESS STEEL WORLD AMERICA 2004 CONFERENCE & EXPO is being held in Houston, Texas, U.S.A. on Oct. 20-22, 2004. The focus of the event will be corrosion-resistant alloys (CRAs). The conference will cover the broad range of CRAs being used in the oil and gas processing and power generation industries, and in architecture. Applications and practical field experiences will be emphasized. End users, fabricators and producers will present information on how to manage costs and improve reliability. That information will take the form of case histories and shared experiences in the design, fabrication, specification and management of CRAs. Topics include: rouging; clad materials; weld overlays; risk-based inspection; failure analysis; welding; high-temperature applications; and sourcing material in developing countries. Contact: Mr. Miel Bingen (Conference Secretary), Stainless Steel World, P.O. Box 396, NL-7200 AJ Zutphen, The Netherlands, Tel: +31 575 585 284. Fax: +31 575 585 284. E-mail: m.bingen@kci-world.com Web site: www.stainless-steel-world.net

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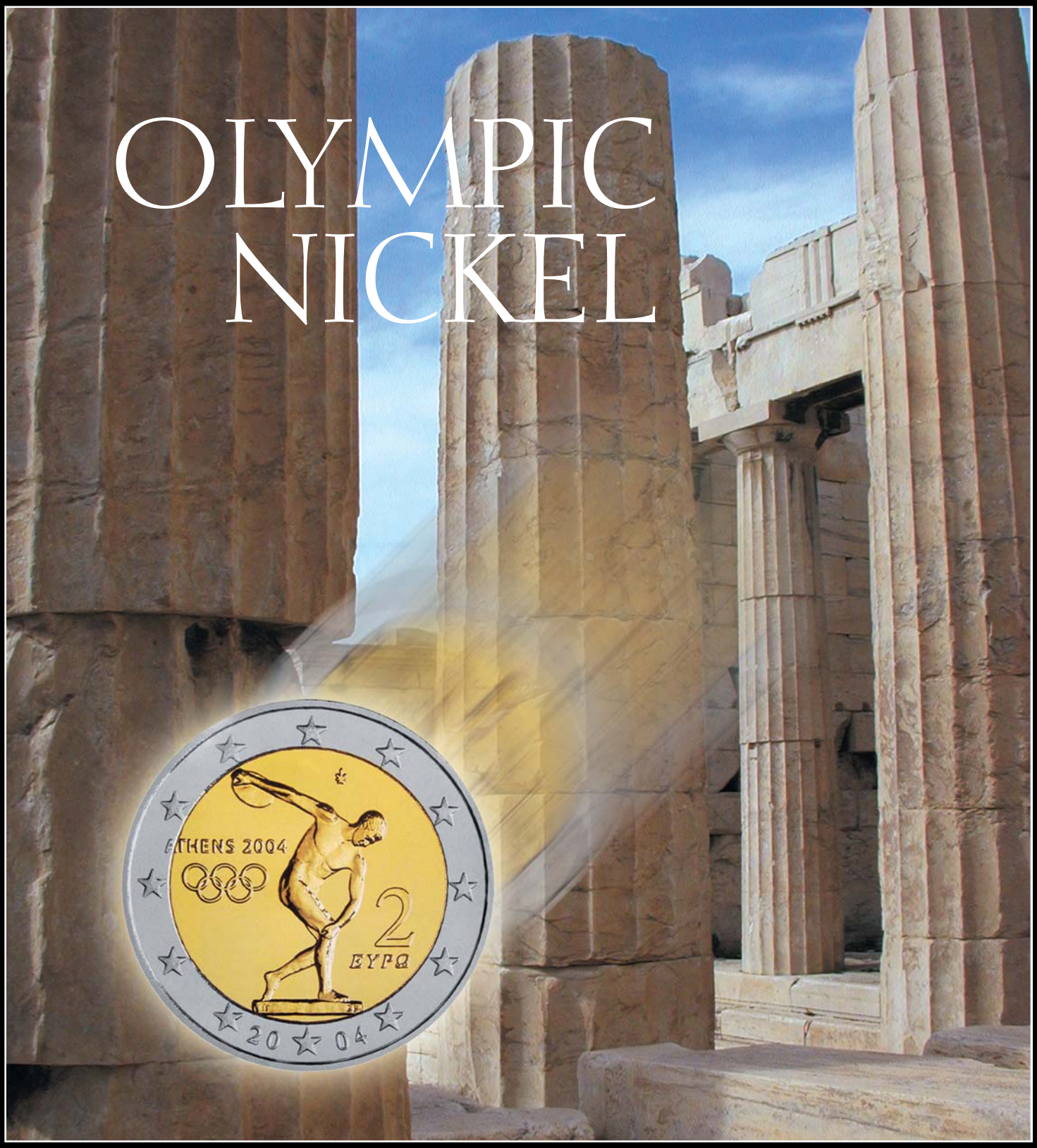
  www.nickelinstitute.org/index.cfm/ci_id/1.htm
- **EUROPEAN NICKEL RISK ASSESSMENT:** Follow the regulatory process regarding the classification of nickel compounds in the European Union.
  www.nickelforum-eura.org
- **THE SCIENCE OF NICKEL:** Understand the science upon which regulations related to nickel are established.
  www.nipera.org

OLYMPIC NICKEL



THE BANK OF GREECE / PHOTOSPIN

About 100 tonnes of nickel have been used by The Bank of Greece in the issuance of a two-Euro coin commemorating the return of the Olympics to Athens in 2004.

The two-euro coin depicts a discus thrower as he twists before releasing his discus, a copy of a statue by 5th century BC Greek sculptor Myron. A Roman-era bronze copy of Myron's statue, capturing the full dynamics and pulse of discus throwing, is housed at the British Museum in London.

A total of 50 million of the coins were issued each weighing 8.5 grams. All two-Euro coins are made of an outer ring of cupronickel, which is 25% nickel by weight, and an inner part which consists of three layers: one of pure nickel sandwiched between two layers of nickel-brass (5% nickel).

For more information on the advantages of using nickel in coins, see: **www.nickelinstitute.org/coins**