

# A mineral for all seasons

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NICKEL

**Is the outlook for nickel bullish or bearish? Which applications are likely drive future growth? This survey examines recent trends, compares supply and demand, identifies new and growing applications and describes some of the many ingenious new alloys that have recently been developed for increasingly aggressive environments.**

## INTRODUCTION

Nickel has risen sharply in recent years – by an average of 4 per cent, according to the Nickel Institute. However, despite short-term uncertainties about supply, the availability of the metal in the long-term should not be a cause for concern: not only is nickel the fifth most common element on earth, several mining projects and capacity expansions are planned or are about to come on-stream. The demand comes from the fact that several growth industries – for example oil and gas, aerospace, power generation and desalination – are finding increasing uses for nickel alloys. Nickel is also gaining

a reputation as an "enviro-metal", especially for its role in cutting emissions in the petrochemical and chemical industries. Low maintenance and ease of recycling are other factors that make the metal a key element in sustainable technologies.

## SUPPLY PROBLEMS

The price of nickel has been rising sharply since 2001. In mid-2005 it faltered briefly, along with that of stainless steel, before resuming its upward march at the end of the year. Various factors have contributed to this state of affairs: supply has not kept up with demand, companies continue to develop

nickel alloys that can withstand ever more aggressive conditions, and demand from China has massively increased.

Price fluctuations can cause problems for end users. The just completed Nanhai Petrochemical Project is a case in point. Ross Prior, Bechtel's Manager, Functions, for the project, told me: "Manufacturers should try to obtain nickel stocks on a long-term basis to avoid market fluctuations, so that customers are offered steadier prices." Supply problems can be attributed to various factors, including a long delay in the start-up of Inco's gigantic Voisey's Bay project in Canada (it finally came on-stream in September 2005) and teething problems with the first generation of pressure acid leaching (PAL) projects in Australia. At the same time, nickel consumption in China rose dramatically from under 5 per cent of global consumption in 1999 to more than 11 per cent in 2004. In 2005 demand was also strong in Europe, especially in Italy and Germany. At first sight nickel seems

destined to go the way of other commodities such as gold, uranium or oil, with runaway price increases due to increased scarcity and soaring demand.

### NEW CAPACITY TO THE RESCUE

While most analysts assume that the bull market will continue in 2006, others believe that stocks have already risen sufficiently for prices to ease off. Whoever is right, there are reasonable grounds for assuming that the squeeze may not last longer than about 2008-9, when a number of projects and capacity expansions are expected to come on-stream. China is rapidly increasing its own manufacture of both stainless steel and nickel. For instance, in December 2005 Jilin Nickel Industry Group, Guangdong Huachuang Group and Canadian Chemical Vapour Metal Refining Inc. (CVMR) agreed to form the Jilin Nickel Industry Group, which now owns China's largest nickel compound production base. China is also financing a nickel and cobalt mining project operated by the Highlands Pacific group in Papua New Guinea. The UK's European Nickel PLC has approved the feasibility study for the Caldag nickel project in western Turkey (conveniently located for the European markets), which it will operate in collaboration with Australian Aker Kvaerner. Inco is constructing its 60,000tpa Goro nickel-cobalt project in New Caledonia and expanding its operations in Indonesia, and expects to boost production by about 35 percent in 2009 from its 2004 level. Posco Co. has just announced an agreement to build a USD 352 million nickel processing plant with New Caledonia's SMSP in South Korea. Capacity expansions are planned or are also underway in Finland (OM Group's refinery in Harjavalta; the Talvivaara Mine Project), Australia (LionOre Mining International's Lake Johnston project; BHP Billiton's expansion of its Ravensthorpe nickel mine and Yabulu refinery; a new nickel sulphide plant in the Western Areas; Gladstone Pacific Nickel's



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proposed USD 983 million nickel and cobalt refinery in Queensland); the Philippines, where Sumitomo Metal Mining Corp. is investing to supply the Japanese market and Coral Bay Nickel Corp. is expanding its mining and refinery activities; Madagascar (Sumitomo and Dynatec's project at Ambatovy, which is expected to produce 60,000 tonnes of nickel annually); and Brazil (CVRD's USD 1.2 billion Vermelho project, expected annual capacity of 46,000tpa of nickel and 2800tpy of nickel cathode). Russia, the world's largest producer (20 per cent), continues to upgrade its facilities: Norilsk currently spends about USD 50 million annually on new equipment as part of a ten-year, USD 3 billion investment programme. Another unexpected source of increased mining activity is Cuba, which has the third-largest nickel reserves in the world. Among US manufacturers, Electralloy announced in May 2005 that it would expand its remelt facilities, and in September Allegheny Technologies announced a 20 per cent expansion of its melt nickel-based alloy, super-alloy and specialty alloy production capabilities.

### INCREASING APPLICATIONS

All in all then, mining and production are proceeding rapidly and will continue to do so until 2009. But it

remains to be seen whether this new capacity will suffice. Nickel is now used in such a diversity of domestic and industrial applications that it is hard to envisage that demand will let up any time soon. In addition, environmental regulations and shortages of water and energy mean that nickel is finding a use in an increasing number of applications. So it is not only in traditional areas such as architecture, aerospace, oil and gas, power generation and chemicals that growth is occurring, but also in the more environmentally conscious areas like fuel cells, (waste)water, desalination and flue gas desulphurisation. Hybrid vehicles, which use nickel-based batteries, are also driving nickel demand, according to a US Geological Survey report. For a number of applications new austenitic, nickel-based and super alloys are being invented in which nickel is an important for its resistance to corrosion and heat, ease of maintenance and low life-cycle costs.

### LOW-MAINTENANCE BRIDGES

Maintenance, security and life-cycle costs weigh heavily on the government and municipal organisations responsible for the upkeep of large structures such as bridges in saltwater environments. This is why stainless steel 31600 rebar (12 per cent



Steam generation unit at Suncor's Firebag oil sands lease, Alberta, Canada.

nickel) was used in the construction of the Broadmeadow Bridge (built by Arup) in eastern Ireland and in the Shenzhen Western Corridor Bridge in Hong Kong (built by Gammon Constructions Ltd); according to Nickel Magazine, both bridges will be maintenance-free for 120 years.

### OIL SANDS AND LNG

Nickel alloys and copper/nickel alloys continue to be used in conventional oil and gas, and it is especially in oil sands and LNG that use



is likely to grow significantly. In Suncor's oil sands project, the Firebag mining lease in Alberta, Canada, N08926 (containing 25% nickel) is used in the evaporators (manufactured by Ontario-based Associated Tube Industries) that recycle the water recovered with the bitumen (see photo). The material was selected because of its resistance to corrosion, to pitting and crevice corrosion and to stress corrosion cracking. In November 2005 Imphy Alloys, a company within Arcelor's stainless steel business, provided its Invar® M93 alloy (36 per cent nickel) for ten LNG carriers, with an option for a further ten. The alloy is used in LNG tanks designed with membrane technology, and is designed to transport LNG and other fluids at cryogenic temperatures. The company had already supplied the same alloy for two of Hudong Zhonghua's LNG tankers, and is anticipating further orders.

### NEW ALLOYS

A striking number of alloys are also being invented for use in the chemical, petrochemical and power generation industries. For example, Special Metals has recently come up with INCONEL 693 (UNS N06693),

**Several growth industries – for example oil and gas, aerospace, power generation and desalination – are finding increasing uses for nickel alloys.**

designed to offer resistance to corrosion mechanisms to higher temperatures than was previously possible from a nickel-based alloy. Sandvik Materials Technology cooperated with a phosphoric acid producer to produce Sanicro 28™ grade seamless stainless steel tubes to replace graphite in heat exchangers (see photo). This austenitic is designed for service in highly corrosive conditions. Finally, in spite of pressure on nickel prices and resources, nickel alloys are being developed to replace alloys made of an even scarcer material, titanium. Allegheny Ludlum has invented a number of alternatives to titanium for welded condenser tubing and other severe chloride applications. One of these, the austenitic alloy AL-6XN or N08367 (typically 24 per cent nickel), is designed to offer improved resistance to corrosion in reducing or caustic environments compared to the superferritic stainless steels. Allegheny Ludlum has delivered its AL-6XN Optimized™ alloy, designed for saltwater environments, to the reactor building service-water piping system at a Taipower power plant in Lungmen, Taiwan. The AL-6XN Optimized™ alloy exhibits far greater resistance to chloride pitting, crevice corrosion, and stress-corrosion cracking than exhibited by the standard 300 series stainless steels, and it costs less than the traditional nickel-based corrosion resistant alloys. The drive towards greater energy efficiency, for the sake of both conservation and emission reduction, requires turbines to operate at ever higher temperatures. This has led Haynes International (the inventors of Hastelloy) to develop a superalloy, HAYNES® 282™ (58 per cent nickel), that could be used in seamless forged rings in gas turbines, in aircraft manufacturing and other high-performance, high-temperature environments.

### ENERGY AND WATER

As I write, the UK government is debating about how to find ways to meet its obligations under the Kyoto agreement, and also with

water shortages. Its concerns are shared by governments the world over. In both these areas, already existing nickel alloys seem set to play an increasing role. Wet scrubbers made of nickel alloys are increasingly being installed to resist corrosion from the high-sulphur coals burnt in coal power stations. (For more on desulphurisation equipment, visit: <http://www.stainless-steel-world.com/pdf/10072.pdf>).

The market for desalination also seems set to increase, with projects under way not only in the Middle East but also in dry countries areas like the southern USA and Australia. In Iran, construction of Binak desalination unit is about to begin, and other units are planned, according to a statement made by National Iranian South Oil Company (NISOC) on 22 October last year. In Dubai, the first contract has just been signed for the second phase of "L" station, a power generation and desalination plant. In the USA, demographic change and climate change have conspired to make the southern part of the country especially vulnerable to water shortage. El Paso Water Utility (Texas) aims to complete its inland desalination facilities at Fort Bliss by the spring of 2007, while California has just proposed a huge desalination plant at Huntingdon Beach. In Australia, a desalination plant at Kwinana, south of Perth, is due to open later this year, while other plants are contemplated for Sydney and Gold Coast City. However, critics –

among Prime Minister John Howard – oppose the plans on the grounds that recycling consumes less energy.

#### FUEL CELLS

The two most common methods of turning salt water into drinkable water are multi-stage flash distillation (MSF) and reverse osmosis (RO), both of which use nickel-containing materials. These nickel-containing duplex, super-duplex and super-austenitic stainless steels offer higher strength and corrosion resistance than standard stainless steel grades. Allegheny's AL-6XN, mentioned earlier, has been specified for several water treatment plants recently, because it can be used in thinner sections than copper-nickel alloys, saving weight and cost.

Finally, nickel alloys can play a role in fuel cells for hydrogen power generation. As conventional power generation gets more expensive, and hydrogen power generation gets cheaper, we approach a tipping of the scales in favour of hydrogen power. FuelCell Energy Inc. is one company that is betting that high costs for conventional electricity will favour its fuel cells made of nickel and stainless steel (Virginia Heffernan, Nickel Magazine, November 2004). Hydrogen reforming requires nickel to make the anodes and cathodes because it is a good conductor of heat and electricity and is resistant to corrosion. In 2005 it was reported that BASF has developed a nickel catalyst for small fuel processors used in the steam-reforming

of natural gas. The low costs are thought to mark progress towards the commercialisation of fuel cell systems for the combined generation of heat and electricity in households (Dr Gerry Crawford, Nickel Magazine, March 2005).

#### THE FUTURE IS CHINA

Nickel's high price and profile is reflected by the institutional consolidation of one of the world's leading nickel professional bodies, the Nickel Institute (formerly the Nickel Development Institute). In July 2005 the European operations of the Nickel Institute were merged with those of the European Nickel Group, which had been operating in Brussels under the administrative wing of Eurometaux. The new organisation, known as the European Nickel Industry Association (ENIA), chose Brussels as its base because of the increasing regulatory and political importance of the EU (Nickel Institute press release, 4 July 2005). Yet, whatever the importance of Europe, China seems likely to remain the "swing" economy that will determine whether or not the next few years will prove bullish or bearish for nickel. The Nickel Institute nailed its banner to the mast of Chinese growth in May 2005 when it launched its Chinese website. While no one can predict the future with complete accuracy, this confidence seems well founded: from process industries, oil & gas, energy and infrastructure to high-quality cookware and CDs – China seems to have it all where nickel is concerned. With prospects looking good in the rest of the world as well, demand is likely to remain high for this versatile, long-life mineral, at least in the next two or three years. ■

Sandvik's stainless steel tube grade Sani-cro 28™, designed to replace graphite in heat exchanges. This austenitic stainless steel is characterised by very high corrosion resistance in strong acids, particularly against pitting and crevice corrosion, very good resistance to stress and intergranular corrosion in a range of environments, and good weldability.

