Nickel-Back

Dr Tim Johnson, technical director at Tetronics International, asks if it's time to recycle more nickel… as the headline says, is it time to get our nickel back?

Now you might think me a little sad, but I have to confess that, as a metallurgist, I always find it interesting just how closely the history of mankind is linked to advances in metal working. The first evidence of metal working in Europe dates from around 5500 BC, with the extraction of copper, lead and precious metals and this was followed by the working of bronze from around 4000 BC, both of which mark key points in the emergence of modern civilisation more generally.

The growing use of new techniques to extract iron from its ores in around 1200 BC then marked the transition to the iron age, a period of time that only came to an official end in around 600 BC as pre-history transitioned to history with the widespread use of writing.

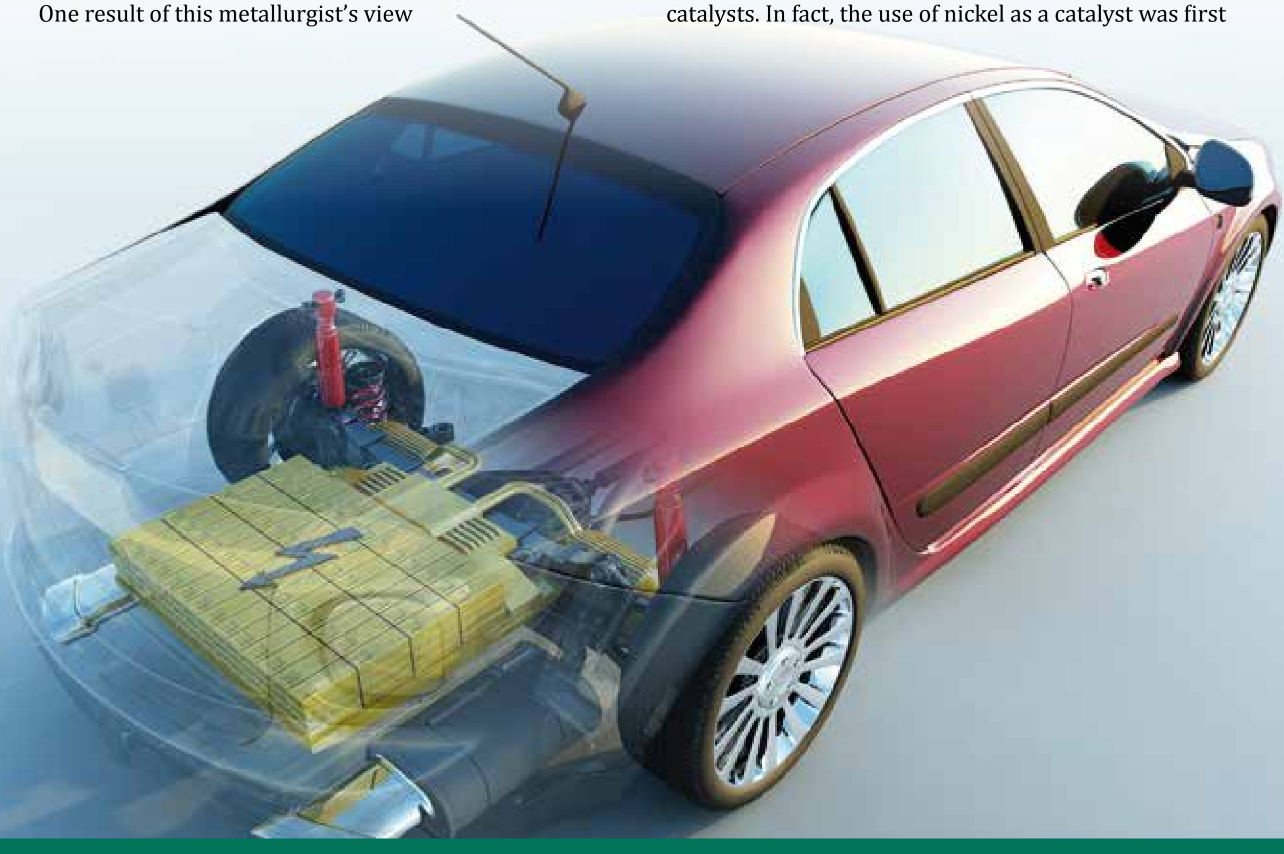
Rather later on, the industrial revolution was largely triggered by the advent of improved cast iron production methods in the early 18th Century, whilst the rapid industrial expansion of the Victorian period was only made possible by the cheap and plentiful supplies of steel provided by Bessemer's converter and other innovations. It could also be argued that the expansion of air travel and the more recent digital revolution in the 20th Century owe debts of gratitude to revolutions in the production of alloys based on aluminium and silicon respectively.

One result of this metallurgist's view of history is that metals tend to have a kind of historical pecking order, from the venerable metals of antiquity, such as gold, silver, copper, lead and tin, through to the "classical" iron, the steels of the modern age and those upstart "new" metals – aluminium, silicon, stainless steel, rare earth magnets and so forth.

However, there are some metals that eschew such clear distinctions, and perhaps the stand out one of these is nickel. Along with its close cousin, cobalt, it was only recognised as a distinct metal in the 18th Century and both were named after mythical sprites and goblins of the mountains. However, it turns out nickel was also used inadvertently in antiquity alongside copper to make bronze from almost the beginning of the bronze age. So, it would seem this mischievous sprite of a metal has been hiding in the shadows of mankind's history, long before being forced to emerge into the daylight as one of the most important metals of the 20th and 21st Centuries.

Thoroughly Modern Metal

NICKEL NOW reaches into many areas of our lives and, whilst it is mostly used to produce stainless steel, it is also used in many other applications, including rechargeable batteries, coins, a coating material and as a basis for many catalysts. In fact, the use of nickel as a catalyst was first



discovered as far back as 1897 and, although it was displaced somewhat by the use of platinum in the mid-20th Century, it is becoming more important again as a lower-cost alternative in several important reactions, including the hydrogenation of vegetable oils, reforming of hydrocarbons, and the production of fertilizers, pesticides, and fungicides.

As well as increasing stainless steel production, the projected three-fold growth in electric car production will increase from 2015 to 2020 and will support long-term nickel demand as a battery material.

Consequently, the demand for nickel across the whole range of applications has been increasing by around 5.3 percent per year for around the last 40 years or so. This extraordinary growth in demand, which is reflected in other key transition metals, such as molybdenum, cobalt, tungsten and vanadium, means the supply of nickel has to double every 12 years or so. When you consider the average nickel mine (pictured) has a working life of typically 17-22 years, this means that from the time a nickel mine opens until it closes, the industry needs to find the equivalent of another three or four mines of a similar output to satisfy this relentless demand.

It is hardly surprising, therefore, that all nickel mining companies face a combination of increasing metal extraction costs and declining quality of ore. It is extraordinary to think that back in 1880, ores commonly contained over 10 percent nickel; by 2010 "good quality" ores were down to between just one and two percent nickel.

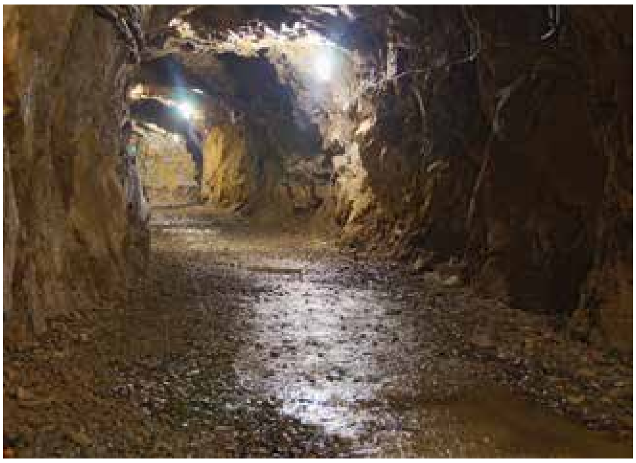
So, with declining ore quality, falling mining output and growing demand, is it time to recycle more nickel? We think so…

Secondary Sources of Nickel

THERE ARE a range of "non-metallic" secondary sources of nickel and other valuable base metals, including electroplating residues, batteries and so forth. However, some of the most interesting arise from the petrochemical industries and especially in catalysts. The use of these metals as catalysts has been known for over a century and although they were displaced somewhat by the use of platinum in the mid-20th Century, they are increasingly important. Whilst other major sources of nickel wastes, such as scrap stainless steel, are ideal for recycling directly back to the steel industry, petrochemical catalysts are both less plentiful and less suited to many recovery routes.

Nickel, cobalt, molybdenum and other valuable base metals have been recovered from a wide range of sources using various hydrometallurgical and pyrometallurgical methods. These methods include DC plasma smelting, roasting with sodium salts followed by either neutral leaching and alkali digestion or acid leaching, and acid leaching and chelation.

Tetronics' DC Plasma Arc technology is one of several pyrometallurgical solutions available for the recovery of valuable base metals from secondary sources, the other key ones being shaft furnace and submerged arc furnace smelting. Shaft furnaces and submerged arc furnaces are both typically used at tonnages of more than 10,000 tonnes per month of alloy output, which is likely to be an order of magnitude larger than the typical furnace output that could be justified by the availability of many of the secondary sources of nickel, such as spent catalyst.



By contrast, Tetronics' DC plasma smelting technology is ideally suited to operating at these lower annual tonnages. Over the years, this technology has proved itself to be very adept at extracting nickel and other key base metals from dusts generated in the melting and production of stainless steel.

Plants in Italy and the UK have been processing these wastes for 25 years for recycling back to their adjacent steel plants in place of metals extracted from mining operations, in one case leading to the realisation of $190m of value from these wastes over a 20-year period. For the last 10 years or so, Tetronics' plasma smelting plants have been used for extracting precious metals from industrial catalysts and catalytic converters. As the use of nickel as a catalyst in chemical processes is expanding, so these two strands of Tetronics' experience have come together to produce a growing interest in the recovery of nickel from petrochemical catalysts.

Tetronics' technology is ideally suited to the lower annual tonnages and varied chemistries of many secondary sources of nickel because of several key features, including its ability to operate with a wide range of feed materials, tight control of smelting conditions and ability to treat dusty materials without pelletising as a result of the low gas flows associated typically with DC plasma arc-based processes. The high furnace temperatures and the ability to vary the reaction conditions of the process also allow the operator to separate the elements in the charge into gaseous, slag and metal fractions. This, in turn, maximises the value derived from the waste and minimises the secondary waste arising, whilst achieving low ultimate emissions to air and water.

So, as the world looks for new environmentally-friendly methods to satisfy the relentless growth in demand for nickel, the highly compact, environmentally friendly and efficient nature of Tetronics' DC plasma smelting technology means it is sure to make an increasing contribution to the recycling of these increasingly important niche secondary sources of nickel. ■

Dr Tim Johnson is a technical director with a plasma and engineering focus particularly in the areas of waste reuse/ recovery and clean heating. He spent eight years as a research fellow at the University of Birmingham, coordinating the work on its large plasma melting facility.