While many are claiming 2013 as the 100th anniversary of stainless steel, the year of its discovery is not universally accepted. “This view comes from England, but the French, the Germans and even the USA can point to different starting points in the material’s history,” begins Scurr. The first milestones date back to the 18th century, starting with the discovery of nickel in 1751 by Axel Frederick Cronstedt, a Swedish scientist. A few years later, in 1778 another Swede, Carl Wilhelm Scheele, discovered molybdenum and two decades later (1797), a Frenchman named Nicolas Louis Vauquelin identified chromium. “As early as 1820, references to the corrosion resistant properties of chromium in iron were already being noted,” Scurr says, “but the ability to control carbon in steel prevented any useful development.” Then in 1872 in Britain, Woods and Clark filed for a 30-35% chromium, 2% tungsten steel alloy, described as an ‘acid and weather resistant steel’, which is believed to be the first patent of a material that could now be considered a stainless steel. Modern-day stainless steels began to be researched, patented and manufactured in the early 1900s. From 1904 to 1906, Leon Guillet of France did research into iron-chromium alloys – the basis for many of today’s martensitic stainless steels – and iron-chromium-nickel alloys – the basis for today’s austenitic stainless steels. But the findings were not well documented and, in particular, the potential corrosion resistance properties were not recorded. This was left to Philip Monnartz of Germany, who reported on the relationship between the chromium content in steel alloys and corrosion resistance in 1911. The first true patents of what is now considered to be a stainless steel emerged in 1912 when two Germans at the Krupp Iron Works, Eduard Maurer and Benno Strauss, patented a 21% chromium, 7% nickel alloy. This was the forerunner of the austenitic 18/8 (18% Cr, 8% Ni) or 18/10 (18% Cr, 10% Ni) stainless steel grades, commonly referred to as the 300 series. “The chromium-nickel-manganese grades, the austenitic 200 series were also investigated at this time, but had to wait until the 1950s, during the Korean war, before manganese began to be used commercially in stainless steels,” adds Scurr. Then, 100 years ago in 1913, the English emerged with a development that is broadly accepted as the start of the commercial development of stainless steel. “A researcher called Harry Brearley made a cast of a martensitic stainless steel in Sheffield, which he called ‘a rustless steel’. A colleague of his, Ernest Stuart coined the phrase ‘stainless steel’ a short while later,” Scurr relates. “These heat treatable martensitic stainless steels were soon used in the production of knives, whose blades remained sharp and rust free,” he adds – and Sheffield is still renowned for its cutlery today. A few years later in the USA, Christian Dantsizen developed began to develop the ferritic stainless steels, which generally require lower carbon content, while the stainless steel that is today one of the most technologically...
interesting, the duplex grades, can be traced back to Avesta in Sweden in the 1930s. “The development of these alloys was delayed, though, by several more decades because of inadequate steel making technology.”

On the processing side of steelmaking, the Bessemer process was introduced in the 1850s and in that century, there were several developments, mostly involving carbon control, some of which also covered the control of carbon in iron-chromium alloys. “But the most significant single invention in the stainless steel processing field was the argon/oxygen decarburisation process or AOD. It was invented in 1954 in the USA by Union Carbide and it drastically changed the industry from a cost point of view. AOD enables large quantities of stainless steel to be smelted at low cost, and low carbon or L-grades to be produced,” Scurr explains.

An overview of stainless steel grades

“Stainless steel is now conventionally defined as an alloy of iron and chromium with controlled amounts of carbon. To be a stainless steel, the alloy must have at least 50% iron, and if it less, then we say it is a stainless alloy rather than a stainless steel,” Scurr notes.

For corrosion resistance, stainless steels require a minimum of 11% chromium, because it is chromium oxide that forms the corrosion resistant passive layer on the material surface. Carbon contents can be from very low (less than 0,03%) to greater than 1,0%, depending on the alloy, and the addition of nickel, molybdenum, nitrogen, titanium, copper, niobium, sulphur and selenium, amongst others, can be added to confer a range of attractive and exploitable properties.

“What we end up with is ‘family tree’ of stainless steel alloys and grades with an ever increasing range of applications,” suggests Scurr.

The plain chromium side of Scurr’s suggested ‘family tree’ starts with the martensitic and heat treatable chromium stainless steels. “These are generally not very good from a welding point of view, so are not widely used for general fabrication,” he advises.

The next branch up contains the ‘so called super ferritics’, which are high chromium alloys that usually also contain molybdenum. They have very good corrosion resistance, very low carbon content and are widely used for condenser tubing on a nuclear power stations, for example, when seawater is used for cooling.

Generic ferritics are also on the plain chromium side of the tree. “These are used for kitchen sinks, catering utensils; and extensively in the automotive industry, which is probably the biggest consumer.” On an offshoot from this branch are the utility ferritics, such as the South African-developed 3CR12.

“Generally, due to grain growth and reduced toughness after welding, ferritic stainless steels are limited to thin gauge use, below about 3,0 mm. In contrast, 3CR12 is a weldable grade that is suitable for use at thicknesses of up to 30 mm,” says Scurr.

Moving across to the nickel containing side of the tree, Scurr says this is dominated by the well known 304 (18/8), and 316 (18/10) austenitic stainless steel alloys. Offshoot branches also include some higher chrome, heat resistant alloys for high temperature (up to 1 200°C) in oxidising conditions or furnace environments, for example. “The austenitic stainless alloys, such as the nickel-based alloys also appear here, although these are not strictly stainless steels, they are stainless alloys,” he reiterates.

The combined family finds uses in a host of different applications. “The use for of stainless steel for railway cars is topical in South Africa because the Passenger Rail Agency of South Africa (PRASA) has just awarded the contract for new passenger rail coaches – and the material of construction is likely to be austenitic stainless steel,” predicts Scurr. “As well as corrosion resistant properties, austenitic stainless steel can be work hardened on rolling, which gives it very good mechanical and toughness properties.”

Citing newer applications in architecture, Scurr shows a slide of the DNA Bridge in Singapore. “They used 2205 duplex for this bridge, not only for its stainless and aesthetic properties, but to make maximum use of the material’s mechanical properties. We are starting to see duplex making inroads into structural applications long dominated by carbon steel.”

Turning attention to the stainless steel industry in South Africa, Scurr says that we have 85% of the world’s reserves of chromite and the capacity to meet 50% of total global demand for ferrochrome. “We currently only supply 30%, though, and this is largely self-inflicted. We are limited by the electricity supply and Eskom is currently paying producers not to make ferrochrome. This has allowed the Chinese, who have no chromite ore resources, to become the world’s biggest ferrochrome producers,” he argues.

Ferrochrome production began in

One of the earliest uses of the South African-developed 3CR12 utility stainless steel was on the Richards Bay coal line in the mid-1980s. During the last examination of these wagons by Columbus Stainless in 2012, no measurable material loss or pitting was found, after nearly 30 years of service. Photos courtesy of Columbus Stainless.
BENDING AND FABRICATION LIMITATIONS LIFTED COUNTRY WIDE!

REDUCE FABRICATION COSTS AND IMPROVE ENGINEERING DESIGN BY UTILISING OUR NEW 12 METRE X 2 000 TON PRESS BRAKE

We bend mild steels up to 25mm over 12 000mm
We bend Q & T steels up to 22mm over 12 000mm
We bend stainless steels up to 20mm over 12 000mm

WE CAN BEND MUCH THICKER OVER SHORTER LENGTHS. Please call to enquire.

- We also cut (Laser, Plasma, Flame) up to 13 000mm long & 3 000mm wide
- We now roll up to 50mm over 3 000mm (much thicker over shorter lengths)
- We carry a comprehensive range of stock in ferrous and non-ferrous metals
- Contact our sales team to discuss your individual requirements
- Please visit our website for full details
- Trade buyers are welcome
- We deliver

CONTACT US
+27 11 062 3200 • www.generalprofiling.co.za • sales@generalprofiling.co.za
Middelburg in 1964 and, in 1965, Southern Cross Steel was built on the same site to create an integrated speciality steel making facility. “Middelburg Steel and Alloys, now Columbus Stainless, is currently part of the global Acerinox Group.

“The 3CR12 utility ferritic stainless was invented at Middelburg Steel and Alloys in 1977 and commercialised in 1981, providing a weldable, low cost, utility stainless steel to fill the gap between carbon steel and the traditional stainless steels. And the concept has certainly been exploited.

“One of its earliest uses was on the Richards Bay coal line in the mid-1980s, and Columbus still keeps a close watch on these wagons. During the last examination in 2012, no measurable material loss or pitting was found, after nearly 30 years of service,” Scurr reveals.

**Global perspectives**

Globally, Scurr says that stainless steel consumption has risen from 1.0-million tons in 1950 to 35.4-million tons in 2012, representing compound annual growth of 5.6%. The regional share of stainless production is shifting, though, he warns. “In 2005, China produced 13% of the world’s stainless steel. By 2012, this had already increased to 45% and most believe that it is now over 50%,” he points out. “When you consider that we in South Africa have over 50%,” he concludes. “Our Government needs to use the tools at its disposal to act against unfair imports and to add more support for the development of a competitive local stainless manufacturing industry,” Scurr concludes.

South Africa? “The export market for catalytic converters has been a success story for South Africa. “Supported by incentive schemes like the Motor Industry Development Programme (MIDP), we have managed to put together a high-value exports market, and catalytic converters fall into this category mostly because of platinum, rather than stainless steel. This industry is also under threat due to changes in incentive levels under the new Automotive Production and Development Programme (APDP) scheme, the replacement for the MIDP. “We are also very successful at manufacturing and exporting stainless steel ISO-tanks and companies such as Welfit Oddy in Port Elizabeth have captured some 25% of the global market,” he says. “At first glance, the future seems good, with ongoing growth, but if you scratch the surface, you unveil some worrying facts. Last year, import totaling 10 000 t of consumer ware arrived on our shores. This is a huge threat to the stainless steel industry of South Africa, to local manufacturing and to local jobs. Most of these products can and should be made here,” he warns.

**Why is stainless steel stainless?**

Iron and steel corrode relatively quickly because of the reaction between surface metal atoms with oxygen and moisture in the air, a reaction that produces hydrated iron-oxides (Fe₂O₃·nH₂O) on the metal surface – commonly known as rust. Atomic iron is much smaller than its oxide, so the oxide cracks and flakes off the surface, further exposing virgin metal to the atmosphere.

The chromium in stainless steel combines with oxygen in the atmosphere to form a thin, invisible layer of chrome-containing oxide, called the passive film. The chemistry of this passivation layer is chromium(III) oxide (Cr₂O₃). The sizes of chromium atoms and their oxides are similar, so they pack neatly together on the surface of the metal, forming a stable layer only a few atoms thick. The layer is too thin to be visible, so the metal remains lustrous, and is impervious to water and air, protecting the metal beneath. Also, this layer quickly reforms when the surface is scratched. This phenomenon is called passivation and higher chromium content in the steel produces stronger passivation layers and better corrosion resistance.

The passive film requires oxygen to self-repair, so conventional stainless steels have poor corrosion resistance in low-oxygen and poor circulation environments. In seawater, chlorides from the salt will attack and destroy the passive film more quickly than it can be repaired in a low oxygen environment. In such environments, highly alloyed stainless steels or stainless alloys can be used to overcome this problem.