Nickel throughout the wine-making process
Safety, efficiency and beauty in commercial kitchens
India’s increasing use of nickel in food processing

FROM FARM TO FORK
the essential part nickel plays in food production
In the middle of a cornfield, near a small town in Kentucky, an innovative, state-of-the-art bourbon distillery is set to open its doors. Situated on 40 hectares, the 3460 square metre facility is being erected at a cost of US $25 million. When it starts production it will have a 5.7 million litre capacity with the ability to easily expand to 22.7 million litres without disrupting the current design. It will be the largest new distillery in America.

But Bardstown Bourbon Company will be more than just another distillery. With Master Distiller and Bourbon Hall-of-Famer Steve Nally leading the distilling team, a combination of art, science and time-honoured techniques will be used to produce the finest whiskeys, including bourbons and ryes. “Everything is transparent here,” he said. “We even put glass panels in our column still so visitors and clients can see every step of the process.”

The 15 metre tall, custom made, one metre diameter stainless steel still, made by Louisville’s Vendome Copper & Brass Works, features large clear panes where you can see the liquid churning and swirling in the vat. At night, you can stand outside and watch the liquid bubbling inside the still and follow the entire distilling process through the glass walls.

The facility is shaping up to be a true farm-to-fork experience with restaurants on-site offering local fare and plans for an on-site hotel in the future.

Another sign of the American spirit...but this spirit is bourbon!

The custom-made Type 304 nickel-containing stainless steel still

A #4 finish was chosen for the exterior of the vats for washdown and for appearance. And the manway covers and various trim pieces were polished to a mirror finish to add an ornate presence.

MORE THAN JUST A PRETTY SURFACE

Enter a modern, state-of-the-art distillery and you are bound to see gleaming, mirror-polished, nickel-containing stainless steel vats dazzling your eyes. But when Rob Sherman, Vice President of Vendome Copper & Brass Works Inc., set out to choose the finishes for the vats at Bardstown Bourbon Company’s new facility, he had to consider more than just the beauty of stainless. He had to examine the rigid hygiene regulations, food standards practises and of course the economics. Will the material be durable enough for the raw materials and will it require little maintenance?

These considerations led to the choice of Type 304 (UNS S30400) stainless steel. The properties of 304 matched up well with the process and the raw materials that would be in constant contact with the surface.

The interior of the still is a 2B mill finish, which exceeds recommendations for surfaces in contact with food, is smooth enough, easily cleaned and consequently suitable for distilling.
FARM TO FORK

Food supply and food safety are very much current issues across the globe. According to the World Health Organisation, one in ten people fall ill each year from eating contaminated food and 420 thousand people die each year as a result, with young children at particularly high risk. These statistics urged the WHO to dedicate World Health Day in 2015 to “Food safety: from farm to plate, make food safe.”

Regulators around the world are also taking food safety seriously. The Food Safety Modernisation Act in the US; China’s 2015 revision to the Food Safety Law; tightening of regulations on food contact materials in India, and in Europe EDQM’s Technical Guide on Metals and Alloys Used in Food Contact Materials and Articles are just a few examples.

All agree that food safety starts with rigorous hygiene, and nickel-containing stainless steels have long played a vital role in this respect at every link of the food chain. Stainless steel has a noble history. First developed in the early 1900s, it was quickly recognised as an ideal material for food contact applications, with an early example being the splendid stainless steel kitchens of the luxury liner, the Queen Mary, launched in 1934.

Because it is easy to clean, stainless steel is the ideal material for environments where strict hygienic conditions are important. And nickel-containing stainless steel’s corrosion resistance means it is inert, leaving the taste and appearance of foods unchanged. Today, more than 20% of all stainless steel produced goes into products related to the food and beverage sector. In this issue of Nickel, we look at the role nickel plays in the food supply chain from the milking parlour, to food and beverage processing equipment and cutlery. Literally from “Farm to Fork”.

Clare Richardson
Editor, Nickel magazine

1 European Directorate for the Quality of Medicines & Healthcare
The maturing of wine calls upon ancestral know-how and methods, but also on the most up-to-date techniques and materials. From vine to glass, and including the subtle stages of wine-making, stainless steel plays an important part in every stage of the process.

**The harvest**

Grapes are gently removed from the vines with the traditional method of hand harvesting. The stainless steel blades of the secateurs skillfully grasp the grape clusters through the dense leaves around the branch tendrils and remove them from the vine. It’s a labour of love, and a very expensive process.

Today many vintners are opting for special machines which straddle the plants, shaking the vegetation with threshers causing the grapes to fall into a recovery mechanism combined with an embedded sorting system that removes the leaves.

To avoid any corrosion of the equipment and preserve the integrity of the grape, all the parts in contact with the clusters; connecting rods, power transmission chains, threshers, buckets and receiving plates, are made of Type 304L (UNS S30403) stainless steel.

**Crushing, pressing and fermentation**

Once collected, the harvest is immediately routed to the winery to limit oxidation and optimize wine-making conditions. In the winery, the clusters are placed in a rotating cylinder for stripping in order to remove the grapes from their “skeleton”, or stalk.

At this stage, the grapes for red wines and white wines take different paths.

For the reds, once destemmed, the grapes enter the pressing process, followed by the maceration step in stainless steel vats that place their juice (must) into close contact with the solid particles: skin, pulp and seeds. This process can last several weeks while fermentation occurs and the solid parts—skins and seeds—agglutinate in grape-cake. The grape-cake is removed from the vat and pressed to extract the “press wine” which is returned to the vat for a second fermentation.

For white wines, the harvest is rapidly stripped and the grapes are poured into a metal hopper and pass between rollers that will burst them to extract their must but without crushing the pulp or breaking the seeds that could release their components. When the must deposit is removed, alcoholic fermentation transforms the sugars into ethanol by the action of yeasts, in clear juices free of skins and solid particles. This takes place in stainless steel vats featuring integrated thermal regulation systems. It lasts from a few hours (sweet white wines) to several days (dry white wines) depending on the type of wine sought.

For both red and white wines, several steps of racking and must settling allow the wine to be separated from its lees (residual yeast) and other scale producing residues that deposit at the bottom of the vat during fermentation. The addition of sulfites (sulfur dioxide/SO\textsubscript{2}) protects the wine from oxidation and prevents the formation of fungi and molds. These stages involve transferring the wine from one vat to another. Ease of cleaning the stainless steel vats is essential for time and labour savings and to ensure that unwanted microorganisms are not present to spoil or alter the taste of the final product.

**Blending and bottling**

The blending of several grape varieties, with complementary qualities, can then take place...
in the vats in order to obtain the best vintages.

Before bottling, the wine passes through plate filters, earth filters, or better yet, mesh or ball filters made of Type 316L (S31603) stainless steel that capture the last impurities without altering the taste of the wine or releasing polluting waste.

**The stainless vat advantage**

While wood continues to be a legacy material of choice for vats in the most prestigious wineries, its use remains for the most part artisanal. It requires great care, is sensitive to microbial contamination, is a poor conductor of heat and provides an imperfect seal.

The advantage of concrete casks is their airtightness and good thermal inertia. But they are hard to clean as the acidity of the wine attacks the walls and the built-in construction makes any subsequent fit-out of the cellar complicated.

For these reasons, stainless steel has seriously come into play, with clear advantages in the installation, operation and maintenance of a high-performance fermenting room.

Wine-making vats, vats for storing red wine and temporary vats for white wines are primarily made of Type 304L stainless steel. This grade is ideal for moderately aggressive environments and containers not intended for long-term storage.

The addition of molybdenum for improved resistance to corrosion makes Type 316L stainless steel well-suited to white wines whose fermentation must be highly controlled. In particular, it is used for sweet wines that are more aggressive due to the addition of sulfur. Type 316L is also suitable for rosés, alcohols and fortified wines.

Tailor-made vats, manufacturing flexibility and the ease with which nickel-containing stainless steel adapts to these technically advanced designs has enabled the production of truly spectacular wine cellars.

Playing a key role in every stage of the process, it’s clear that stainless steel and wine-making will continue to be a successful blend for vintners in the years ahead.
Dairy cows can seem gentle creatures—and for the most part are. But with an average weight of 475 to 700kg, they can cause damage if they lean against barriers or piping and can pack a hefty kick or a targeted neck swing if irritated. To the farmer, strength and toughness to resist battering are important for housing barriers as well as food and water dispensing equipment. And longevity, corrosion resistance against excrement as well as disinfection and ease of cleaning are also required. Cow manure is a beneficial fertiliser for gardens and fields and plays its part in biogas production but as slurry in farm buildings, it does have its drawbacks.

At the milking parlour, hygiene becomes paramount. Daily washing down, sterilisation of pipework, milking equipment and tanks are carefully carried out. Milk is monitored for bacteria counts and if it is not very strictly controlled, can be rejected. For a market in which profits are narrow, problems such as mastitis and milk contamination can be catastrophic for the farmer. As herd numbers increasingly grow and there is a move from herringbone and rotary parlours towards even more sophisticated robotic systems, the choice of materials becomes more selective too, for camera-controlled milking arms, cabinets for data display control panels and ancillary equipment such as floor plates to avoid slipping, parts of foot-trimming crushes and ventilation blowers and ducts.

Stainless steels have been successful in transforming the dairy industry for over 60 years. They have ideal strength and corrosion resisting properties for the range of required applications and form the core equipment used throughout. Grades used are primarily Type 304L (UNS S30403) and Type 316L (S31603) stainless steels although duplex alloys are now being used under more exacting conditions. Stainless steels are hygienic because they have smooth bright surfaces which are eminently cleanable and can remain so with time. Strict standards of hygiene are therefore possible at every stage of its use. Stainless steel behaves neutrally and does not alter the taste or smell of fresh milk or milk products nor does it react with the lactic acids formed by fermenting milk.

The composition of fresh milk can vary widely between different breeds and during different stages of lactation but typically contains about 87% water. The remainder consists of solids in the form of lactose (carbohydrate), fat, protein, and minerals. The pH normally lies between 6.6–6.8. Milk arrives from the cows’ udder at 35 °C. It is very quickly chilled down to 4–6 °C to prevent bacterial growth, and is kept in tanks usually equipped with stirrers or agitators to await collection. Heat exchangers are an important part of the dairy industry for cooling and heating, and are used to extract the heat from the raw milk. In some cases the heat is further used, for example in pre-heating wash water or space heating. Stainless steels are also used for the truck mounted milk tanker vessels which transport the milk from the parlour tanks to factories for further processing. Whether the milk is pasteurised for drinking, further dried as milk powder or goes on to make cheese, yoghurt, butter or ice cream, stainless steel equipment is necessary to meet very strict hygiene standards.

Robotic milking parlours, here manufactured by Fullwood Ltd using Type 304L stainless steel, take a new approach to traditional methods as they provide a voluntary milking system for cows. The milking machines connect automatically to the cow’s teats and turn off when the milking is complete. A computerised system ensures that no cow is over-milked. In turn this provides the farmer with more flexibility and time, plus full data about each cow.
Stainless steel milk tanker vessels transport the milk from parlour tanks to factories.

Carrot topping

When shopping for the humble carrot, spare a thought for the effort and technology that goes into bringing to market a clean and wholesome looking commodity. Soil and stones have been removed, haulm (stalks) taken off, they have been cleaned and polished, and graded to size—all before packaging.

In Poland, the fruit and vegetable producer, Polfarm, has recently upgraded their facility by installing a washing and processing line capable of handling 40 tonnes of carrot crop per hour. The washing, grading and processing line is custom built in nickel-containing stainless steel. It includes a large hopper cleaner at the in-feed with separators for the effective removal of soil and haulm from carrots prior to the washing process.

The carrot washing line begins with a 40 tonne per hour cyclone de-stoner followed by one of the largest pieces of equipment in the facility; a 12.5 metre long, 15 tonne capacity wet hopper, offering effective soaking of crop prior to washing. The crop is then transferred to two five-metre long stainless steel barrel washers, four polishers and a large hydro-cooler. The latter helps to increase longevity and shelf-life of the vegetables.

Carrots are then graded by diameter by a series of lift roller graders, and also by length with a number of vibrating length graders, before they are transferred for packing.

The aim of the upgrade is to minimise maintenance and labour as well as increase throughput. UK based Tong Engineering, the equipment manufacturer, believe they have achieved this for Polfarm by good design based on 85 years of engineering experience in this industry and their effective use of stainless steel. Neil Martin, Factory Manager at Tong Engineering says, "Experience has shown that Type 304 (UNS S30400) grade stainless steel is ideal for this application, due to its suitability and longevity in demanding vegetable handling process environments such as washing, polishing and de-stoning, where a great deal of water is used."
In India, food and beverage processing, preserving and distribution are becoming increasingly important—both to ensure the availability of food at a relatively low cost for this vast country’s growing population and to fuel a developing export sector. Because of its climate diversity, India is one of the few countries in the world capable of producing a wide variety of crops and an abundance of livestock year round. And nickel-containing stainless steel is playing a key role in India’s food processing industries through its use in equipment, components and appliances.

**World’s fastest growing economy**

In 2016, India was recognized as the world’s fastest growing economy. By 2020, it is estimated that household consumption in India is set to nearly double. Changing lifestyles and increasing expenditure on health and hygiene mean there is huge potential for growth in the food sector. And rapid urbanisation and a young population, together with growing disposable income have increased the demand for processed food in particular. With its increased integration in the global economy and proximity to key foreign markets, India’s food processing industry is also seeing greater export potential.

The Government of India has been instrumental in the growth and development of this sector. Through the Ministry of Food Processing Industries it is making efforts to encourage investment in the food industry, which seem to be paying off. According to the Department of Industrial Policies and Promotion, the food processing sector in India has received around US $6.82 billion of foreign direct investment between April 2000 and March 2016.

**Opportunity in every segment**

The Indian food processing industry accounts for almost one third of the total food market and is ranked fifth in terms of production, consumption, export and expected growth in the country. It contributes around 14% of manufacturing Gross Domestic Product (GDP) and 13% of India’s exports. Similar to other parts of the world, India categorises food processing into six major segments; fruits and vegetables, milk, meat and poultry, marine products, grain processing and consumer foods. India today is the second largest producer of fruits and vegetables in the world and this sector is expected to grow 25% by 2025. The country is the world’s largest producer of milk, the largest producer of buffalo meat, and second largest producer of goat meat, eggs and broiler meat. It is estimated that India produces 200 million tonnes of different food grains annually. Processed food has been one of the fastest growing segments in the food chain. In particular, demand is increasing for packaged food, carbonated soft drinks, alcoholic beverages and bottled drinking water.

**New mega food parks**

The Confederation of Indian Industry estimates that the food processing sectors have the potential to attract as much as US $33 billion of investment over the next ten years. The Ministry of Food Processing Industries is actively promoting the concept of mega food parks (MFPs). Fourteen new MFPs have been approved and six are now in operation. The Government is also promoting skills development programmes. These are designed to enable the food processing industry to step up to stringent quality and hygiene norms which protect consumer health and are preparing the industry to face global competition.

**A big appetite for Types 304 and 316**

In the food processing sector, stainless steel is used extensively in items including bottling plants, cooking kettles, blenders, mixers, cooling tunnels, storage tanks, bio-tech reactors, digesters, process piping, pumps, valves flanges, and conveyers. Type 304 (30400) and Type 316 (S31600) stainless steels are favoured by Indian manufacturers of food processing machinery. A recent study of the stainless steels market conducted by the Joint Plant Committee, Ministry of Steel, estimated that almost 80% of the requirement in this sector is for Type 304 grade stainless steel and the balance in Type 316. These nickel-containing austenitic stainless steels have been adopted worldwide in the food processing industry and are found to be safe, passing all the technical requirements of food grade safety and
Use of stainless steel in bread manufacturing on the rise in India

In the consumer food processing segment in India today, demand for baked goods, bread, biscuits and other locally popular consumables is growing at a fast rate. With changing eating habits, bakery products have gained popularity leading to mass consumption and mass production. The increased requirements for corrosion resistance, service life and hygiene have seen nickel-containing Type 304 (UNS S30400) grade stainless steel rapidly gaining acceptance in this sector. In a medium capacity plant 1,000 to 1,200 loaves per hour are produced, with approximately four to five tonnes of stainless steel in the manufacturing equipment.

WHERE STAINLESS IS USED IN TYPICAL BREAD MANUFACTURING:

1. Flour Sifter: Type 304 (outer body); thickness 1.2-1.5mm
2. Mixer: Type 304 (outer body); bowl 3mm; outer panel 1.2mm
3. Conveyors: Type 304
4. Dough Divider: Type 304
5. Final Proofer: Type 304
6. Trays: Mild steel with hot dip galvanised (aluminised steel type)
7. Oven: Type 304, 202 (UNS S20200) (outer casing); 1.2 mm; 1 tonne; burner area Type 310S (UNS S31008), supporting auxiliaries Type 304, 202
8. Bread Cooling Tunnel: Type 304, 202 (outer body)
9. Bread Slicer: Type 304

hygiene standards, due to their corrosion resistance, non-toxicity, stable and non-absorbent contact surface as well as cleanability.

Serving up long-term growth and safety

It is estimated that around 50,000 tonnes of stainless steel will be used in India’s food processing sector in 2016 alone. The long-term growth of stainless steel from this sector is anticipated to increase by around 13.4% per annum over the next decade.

The major fabricators of the food processing machinery such as Alpha Laval, Tetra Pak and L&T have been using nickel-containing austenitic stainless steels for the majority of their projects. Food processing companies are creating awareness among health conscious consumers, highlighting indicators of health and wellbeing of the ingredients and promoting the fact that hygiene is best maintained in production lines made with materials safe for food processing. Indian manufacturers of processed food are well aware that stainless steels help maintain the quality of food while processing and inspire consumer confidence. Considering the overall high growth potential, the food processing industry in India has a bright future and nickel-containing stainless steel has an essential role to play.

Final proofer in bread manufacturing
A fifth of all nickel production is destined for food contact materials, primarily stainless steel, which because of its outstanding properties meets the stringent requirements of the industry. To ensure that food is completely safe, standards and guidelines for equipment must be adhered to. Yet there are many different standards, by different organizations, in different countries, with different approaches, even if they have the same ultimate goal. Some standards are mandatory, others are voluntary, and they are regularly updated to address new concerns.

Need for standards

One such concern arose in 2011 when the United States was subjected to a Listeriosis food poisoning outbreak. Thirty-three people died and there were 147 confirmed cases across 28 states. The incident was caused by the bacterium Listeria monocytogenes from contaminated cantaloupes and was linked to a single farm in Colorado. While foods made from raw milk, such as unpasteurized cheese, and ready-to-eat deli meats are known to have the potential to carry Listeria, fruits such as cantaloupe had not previously been identified as sources of concern.

Food and Drug Administration (FDA) officials had found Listeria at the farm in question on dirty, corroded equipment which had been previously utilised in potato farming. The FDA stated that the “equipment’s past use may have played a role in the contamination”. Water contaminated with Listeria was also found on the floor of the packing plant and it was determined that the workers moving around the plant had spread it, as the contaminated water was also found on the cantaloupe conveyor belt.

The FDA considered this Listeriosis outbreak to be “yet another reason to fully implement the Food Safety Modernization Act” (FSMA) which was signed into law on January 4, 2011. The Act aims to ensure the US food supply is safe by shifting the focus of federal regulators from responding to contamination to preventing it, and provides the FDA with the authority to require preventive controls across the food supply chain; perform inspections and ensure compliance; recall contaminated food and ensure imported foods meet US standards.

A stainless steel for every application

While FSMA does not place requirements on which materials should be used for food contact surfaces, other food industry standards such as 3-A clearly favour the use of nickel-containing stainless steel such as Type 304 (UNS S30400) or higher alloyed grades. These alloys are used to fabricate corrosion-resistant equipment and provide an infrastructure that can be easily cleaned and disinfected to prevent contamination such as Listeriosis. Stainless steels are widely used in abattoirs, and a whole host of food production applications, in farms for animal enclosures, feeding and watering stations, milking equipment and milk storage, as well as equipment to collect and treat animal wastes. There is an austenitic stainless steel for almost every food application, from milk and beer, where Type 304 has served the industry well for over 50 years; fish and meat products which may require a higher grade such as Type 316L (S31603); right through to the super-austenitic steels developed to cope with extremely aggressive conditions of soy sauce production.

Not just clean and shiny

When designing food-processing equipment, ‘hygienic’ does not simply mean ‘always clean and shiny’ but rather ‘resistant to the build-up of process soils and easy to clean between production runs.’ It is not just a matter of choosing materials which will not corrode or will not “impart their constituents to the food in quantities deleterious to human health” but ones which can be fabricated into the complex shapes and components such as a quadra-lobe fluid pump or a double mix-proof valve. Nickel-containing stainless steels meet these criteria and their formability, machinability and weldability allow their fabrication to fine tolerances both practicable and economically feasible.
The rough texture of the skin of the cantaloupe is considered to have contributed to the growth of *Listeria monocytogenes*, the species of pathogenic bacteria that causes the infection listeriosis.

Standards, guidelines and best practices

Standards and guidelines can help designers select the best materials for the job. Standards organizations the world over liaise closely: for example, the 3-A Sanitary Standards organisation in the US works with the European Hygienic Engineering and Design Group (EHEDG) which, in turn, feeds into CEN (Comité Européen de Normalisation—the European Committee for Standardisation) to develop food safety standards. And CEN liaises with ISO, the International Organisation for Standardisation, one result of which is standard ISO 22000 Food Safety Management. In China, the rules governing food contact materials are also being updated. The Chinese standard, GB9684, is a compulsory rule governing food contact material and requires that manufacturers clearly indicate the stainless steel alloy used in the product.

Guidelines are the distilled wisdom of people with an expertise in their subject and practical experience in dealing with food safety issues. Active in this area, EHEDG, is a consortium of more than 350 equipment manufacturers, food companies, research and educational institutes as well as public health authorities. EHEDG not only focuses on the materials, design, installation and cleanability of components, but also helps to identify best practices in their hygienic operation, supply and maintenance. It organises seminars all over the world on subjects such as the influence of surface finish on cleanability and the selection of materials of construction as well as all aspects of hygienic engineering and hygienic design. At any one time nearly 400 technical experts world-wide cooperate to update or extend the EHEDG library of over 44 published guidelines including its cornerstone *Guideline No 8: Hygienic Equipment Design Criteria*. www.ehedg.org
Eco-cooking at its finest

The Drunken Duck at Ambleside in the Lake District, UK was recently fitted with a new, custom built, all-electric eco-cooking kitchen. It was fabricated out of stainless steel and incorporates the very latest energy-efficient cooking equipment.

Johnny Watson, Chef at the Drunken Duck, says owner Stephanie Barton and her son Tom were keen to install a new kitchen that was as green as possible.

“It was important that the kitchen not only worked well, but looked great as it would be on show to our customers.”

In cooperation with the Drunken Duck team, CHR Food Service Equipment developed their Eco-Chef cooking block concept to offer the best efficiencies and be robust and fit for purpose.

The restaurant’s tailor-made 3mm Type 304 stainless steel top with 6mm aluminium bonded under plate houses multiphase induction hobs; planchas; two combination steam ovens; a multifunction pan and water baths for slow cooking. And it looks fantastic too.

Having a look into a big commercial kitchen is like looking into a world full of stainless steel. From the counters, sinks, knives and pots and pans, nearly everything in a kitchen can be made with or from stainless steel.

From hospital kitchens, to large restaurants and even school cafeterias, the use of stainless steel in commercial kitchens has become more and more common in the past few decades. This trend is primarily due to the exceptional properties stainless offers for the food industry and the availability of a variety of products and grades.

Each element in a kitchen has its own unique set of requirements, for instance, when designing knives you may need a grade that allows for a sharp edge. Or you may need a grade which allows excellent cold formability for the making of pots and pans. And for each of these attributes stainless steel offers a wide array of grades to choose from.

Nickel-containing grade Type 304 (UNS 30400) makes up the majority of stainless in kitchens where both corrosion and wear resistance is required. This austenitic grade offers excellent formability, is not subject to embrittlement at low temperatures and is generally readily welded. Its corrosion resistance is provided by the formation of a passive layer on the steel surface. The passive layer is continuous and non-porous and, under normal conditions, is self healing. This provides safe containment of the alloying elements. Corrosion resistance is excellent when alloying a stainless steel with chromium and nickel, up to about 18% chromium and about 10% nickel as in the grade Type 304.

Its universal corrosion resistance and ease of cleaning make stainless steel both “stainless” and hygienic, two very valuable properties in food service preparation. From fork to sink, nickel-containing stainless steel plays a vital role in our commercial kitchens.
The secret ingredient in Italy’s culinary love affair: nickel

Italy is known for both its love of food and its love of design. And by virtue of its hygienic properties, corrosion-resistant characteristics and attractive finish, nickel-containing stainless steel has played a notable role in this love affair.

For many years the food industry in Italy has relied on stainless steel as a widely used and effective material. The smooth, impervious surface of stainless steel is able to withstand wear, impact and fluctuations in temperatures while inhibiting dirt and scale accumulation. And the chromium-rich, self-healing oxide layer provides the corrosion protection rather than an applied coating, which may be damaged and degenerate.

Cocoa storage
A prime example of the functionality of this material in Italy’s food industry, is stainless steel used for the storage of cocoa paste, cocoa butter, and chocolate. The manufacturing facilities are equipped with stainless steel tanks of varying volumes and weights all using Type 304 (UNS S30400), which is specifically designed to food industry standards. These tanks are produced in a 2B finish and are welded using the gas tungsten arc welding (GTAW) process. The individual weight of these stainless steel tanks ranges from 900 to 4,000kg and they are completely insulated by mineral wool. Some tanks are fitted with sleeves that allow warm water circulation in the side walls and in the bottom, while other tanks are equipped with gate agitators. The internal stainless steel sheets are 1.5mm thick, while the thickness of the external sheets ranges from 2mm to 3mm.

The ability to easily wash and sanitise stainless steel allows for bacteria to be removed effectively and simply. Tests have demonstrated that stainless steel has a low bacterial retention capacity, making it a very attractive material for the food industry.

Stainless steel complies with the specifications of the 1973 Ministerial Decree, Hygienic Rules concerning packaging, containers, tools, and equipment coming into contact with food or substances for personal use. This specification provides a list of stainless steel grades that may be used for the food industry. The decree was later implemented at a European level through Regulation EC 1935/2004.

Cookware
Italy’s culinary love affair extends to their cookware. With its pristine finish, durability and resistance to dents and scratches, stainless steel is an attractive choice. By combining functionality, hygiene and design along with flavour preservation, an important component in cookware, stainless steel is able to fulfil stringent specifications. Their expertise, know-how, and inventiveness married with the beauty of nickel-containing stainless steel, has allowed Italian designers to produce high quality and beautiful cookware that satisfy their appetite for the exquisite.
Enabling 3D printing of sensors using nickel nanoparticles

Nickel is a metal with excellent corrosion resistance properties, ideally suited for printing applications. However, when utilising inks made from nickel nanoparticles for inkjet printing, particle clusters form that can clog the printer head nozzles.

Researchers have devised a unique method to produce a stable suspension of nickel nanoparticles that do not cluster.

An innovative application for nanoparticle nickel material is being developed through a collaboration agreement with Nano Dimension Technologies, a leading printing electronics company in the area of 3D printing, and Ramot at Tel Aviv University.

Researchers led by Professor Gil Markovich, head of the department of chemistry, have now devised a unique method to produce a stable suspension of nickel nanoparticles that do not cluster. This was achieved using a wet chemical synthesis process, based on the reduction reaction of the nickel compounds and the presence of a capping agent which forms well-defined nickel nanoparticles.

A range of new applications

Potential applications of these well-defined nickel nanoparticles include sensors with a high spatial resolution, using advanced print heads and a precision micrometer scale. Implementing this innovative technology with Nano Dimension's 3D printing process will make it possible to embed sensors within the layers of a PCB (printed circuit board), opening up a world of possibilities for the monitoring of various energies and their derivatives, such as capacitance, magnetism, temperature and radiation.

Notably, nickel functions as an effective barrier against oxidation (diffusion barrier) when used for the production of PCBs. Adequate protection is particularly necessary for nanometric corrosive metals, since oxidation is immediate when exposed to air.

This collaboration with Tel Aviv University, in combination with Nano Dimension’s intellectual property and know-how, has produced exciting new advancements in the development of new ink formulations and a wide range of new 3D printing applications.

Advanced nanoparticle inks allow for rapid prototyping of complex, high-performance multi-layer printed circuit boards (PCBs).

< DragonFly 2020 3D Printer prints high resolution multilayer PCB prototypes in a matter of hours using nano ink technology, advanced inkjet technology and 3D printing.

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**UNS details** Chemical compositions (in percent by weight) of the alloys and stainless steels mentioned in this issue of Nickel.

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FROM GRASS TO GAS...

Fescue and nickel team up to create renewable green energy

Garden grass could become a source of economical and clean renewable energy, scientists have claimed.

A team of researchers from Cardiff University’s Cardiff Catalysis Institute and Queen’s University Belfast have shown that significant amounts of hydrogen can be unlocked from fescue grass with the help of sunlight and an inexpensive catalyst. They have published their findings in the journal *Proceedings of the Royal Society A*.

It is the first time that this method has been demonstrated and has enormous potential in the renewable energy industry. Up until now, the challenge for researchers has been devising ways of unlocking hydrogen in an economical, efficient and sustainable way.

A promising source of hydrogen is the organic compound cellulose, which is a key component of plants and the most abundant biopolymer on Earth. The research team used the process called photocatalysis or photocatalysis whereby sunlight activates the catalyst, that then gets to work on converting cellulose and water into hydrogen.

The researchers studied the effectiveness of three metal-based catalysts — palladium, gold and nickel. Nickel was of particular interest, as it is much more earth-abundant and more economical.

Professor Michael Bowker, from the Cardiff Catalysis Institute reports, “Our results show that significant amounts of hydrogen can be produced using this method. Furthermore, we’ve demonstrated the effectiveness of the process using real grass taken from a garden. To the best of our knowledge, this is the first time that this kind of raw biomass has been used to produce hydrogen in this way. This avoids the need to separate and purify cellulose from a sample, which can be both arduous and costly.”

Nickel plays good samaritan in faster, purer graphene growth

For years, researchers and technologists have been exploring the massive potential of graphene, one-atom-thick sheets of pure carbon, and its future use in everything from advanced touch screens and semiconductors to long-lasting batteries and next-generation solar cells.

But graphene’s unique intrinsic properties — supreme electrical and thermal conductivities and remarkable electron mobility — can only be fully realised if it is grown free from defects that disrupt the honeycomb pattern of the bound carbon atoms.

A team led by Materials Scientist Dr. Anirudha Sumant with the US Department of Energy’s (DOE) Argonne National Laboratory’s Center for Nanoscale Materials (CNM) and Materials Science Division, along with collaborators at the University of California-Riverside, has developed a method to grow graphene that contains relatively few impurities and costs less to make, in a shorter time and at lower temperatures compared to the processes widely used to make graphene today.

The new technology taps ultrananocrystalline diamond (UNCD), a synthetic type of diamond that Argonne researchers have pioneered. The diamond method takes less than a minute to grow a sheet of graphene, while the conventional method takes hours.

Computer simulations showed that a certain crystallographic orientation of nickel (111) highly favour nucleation, and subsequent rapid growth of graphene; this was then confirmed experimentally. These large-scale simulations also showed how graphene forms. The nickel atoms diffuse into the diamond and destroy its crystalline order, while carbon atoms from this amorphous solid move to the nickel surface and rapidly form honeycomb-like structures, resulting in mostly defect-free graphene.

The nickel then percolated through the fine crystalline grains of the UNCD, sinking out of the way and removing the need for acid to dissolve away excess metal atoms from the top surface.

“It is like meeting a good Samaritan at an unknown place who helps you, does his job and leaves quietly without a trace,” said Sumant.
David Mellor’s “designs for the public good” are a class above

Have you ever stopped to think about the design and craftsmanship that goes into the most familiar of domestic utensils—the knives, forks and spoons that are part of daily life? David Mellor (1930-2009), one of the best known 20th century British designers built his reputation on beautiful and functional cutlery which are now modern design classics.

Mellor originally trained as a silversmith at the UK’s Royal College of Art. After early success in 1953 while still a student with the prize-winning Pride range of cutlery, Mellor came to prominence in the 1960s when he received wide-ranging commissions. His 1965 Thrift cutlery in Type 316 (UNS S31600) stainless steel was commissioned by the British Ministry of Public Building and Works as the standard cutlery for government canteens, under the slogan ‘design for the public good’.

And it’s the nickel (11% in Type 316) that gives stainless steel the weldability, ductility and malleability

Many of Mellor’s designs from the 1950s and 60s, including Pride, are still in production. His Round Building factory in rural Derbyshire near Sheffield, UK, brings together design and manufacturing.

Today stainless steel is used extensively in the David Mellor collection. Andrew Cisalowicz, Mellor’s apprentice in 1978, and today factory manager says, “We have made technological breakthroughs in working with stainless steel. For example, for the City range we developed a sophisticated computerised mechanism to provide variable heat levels when welding stainless steel to achieve the required variations of form. And it’s the nickel (11% in Type 316) that gives stainless steel the weldability, ductility and malleability we need to produce our cutlery designs with precision.”

www.davidmellordesign.co.uk

David Mellor’s Type 316 stainless steel City range of cutlery was designed in 1998 and is still in production. Mellor developed new constructional techniques to achieve the unique sculptural form in collaboration with the Cutlery and Allied Trades Research Association. Each piece of cutlery is formed by a unique process of welding together three stainless steel components and is considered a technological breakthrough.