cover story:

BUTTING: Experts in clad piping

In this issue...

- Revolution: a year in stainless steel
- 1st AM oil & gas part certified by Lloyd’s
- Stainless Europe: the EU bounces back
- Metal powders: a niche to watch!

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WE PUT OUR HEAD AND HEART IN EVERY DETAIL.

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Out with the old, in with the new

“Every once in a while, a new technology, an old problem and a big idea turn into an innovation”
Dean Kamen, American engineer, inventor, and businessman, 1991

This issue arrives on your desk together with best wishes from the Stainless Steel World team for a healthy and happy 2018. You probably feel like you’re months into the new year already...but the wishes still apply.

It’s surprising how quickly something new becomes familiar, trusted and feels like it’s been around for ages. I fondly remember when I became the proud owner of the iPhone 1, a truly revolutionary innovation. That first experience of a touch-screen was paired with a sense of wonder and the recognition that this technology was a game changer. Today I can’t imagine not being surrounded by touch screens at home, work and on the road.

To provide a little context on how innovation can change the world and our perception of it, let’s compare the iPhone 6 to the Apollo Space Program, which landed the first humans on the moon from 1969 to 1972.

- Transistors - iPhone has 130,000,000 times more than Apollo
- Clock frequency - iPhone is 32,600 times faster than Apollo
- Instructions per second - iPhone is 80,800,000 times faster than Apollo
- Overall performance - iPhone is 120,000,000 times faster than Apollo

This means that iPhone 6 could theoretically guide 120 million Apollo rockets at the same time.

Remember that next time you think your phone is taking too long to load LinkedIn! The materials industry is a fertile breeding ground for innovation although end users are often fairly conservative and, by necessity, wary of change. After all, if you’re operating a chemical plant you don’t take risks with unproven materials. This friction has the beneficial effect that only truly useful, economically viable and operationally feasible innovations are released to market. You can read about all sorts of new materials developments throughout the issue in both our features and news pages. Perhaps you’ll learn about something new that can help your business?

Truly functional innovation often takes a lot of time and money to achieve. For instance, this month our cover story is from the German company BUTTING, who have recently launched well-researched developments in clad piping such as glued mechanically lined pipes. It took nearly 18 years to achieve but the results have been enthusiastically received and could be of benefit to the entire industry.

James Chater has taken a look at material developments in our industry in his global round up of stainless steel production, fabrication and consumption.

We also have a treat for you this month: a second feature from James in which he focuses specifically on developments within the EU market. In his slightly tongue-in-cheek article he addresses some of the common (mis)conceptions of the market and where it’s heading across the Union.

As always your comments are welcome; if you’d like to be a part of Stainless Steel World magazine in 2018, feel free to contact me to share your company news and innovations, or perhaps even be interviewed. We’re always open to new things!

Best wishes,
Joanne McIntyre
Editor-in-Chief of Stainless Steel World
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Image Wikimedia Commons
BUTTING in Knesebeck…
Experts in clad piping

The use of mechanically lined pipes represents an economically interesting solution in all areas where high pressures and aggressiveness can be found in the media transported. BUTTING is one of the pioneers of this technology and today exports its clad piping products around the world for some of the most demanding and sensitive applications in the oil and gas industry. Stainless Steel World spoke to Managing Director Thomas Schüller about several exciting and unique developments in the company’s product offering; glued mechanically lined pipes, a special mechanically lined pipe and clad pipes with upset ends.

Revolution: a year in stainless steel

The stainless steel landscape is changing fast, whether in terms of production, fabrication or consumption. Production has shifted to Asia at a pace which has left many gasping, especially in Europe, which has had to take drastic steps to adjust. Additive manufacturing is transforming not only whole industries such as aerospace and orthopaedics, but driving the creation of new alloys. Meanwhile, automated welding is streamlining fabrication. Finally, new applications and new industries are blazing a trail in the pattern of consumption, whether in infrastructure, vehicles, ships or biofuels.

Hybrid steel opens up new design possibilities

Jan-Erik Anderson, Ovako’s Senior Group Technical Specialist, explains how the high-tech steel producer’s innovative Hybrid Steel® family is opening up new possibilities to achieve exceptional performance in highly stressed components while also offering the potential for enhanced corrosion resistance.

Communications: a ‘must-have’ tool for a materials engineer

SSW first had the pleasure of meeting Material and Inspection Specialist Mrs. Sari Musch in September 2015 when visiting the Neste refinery at Porvoo, Finland. There, in the company’s central office, she kindly outlined some of her work related to stainless steels. Two years later, SSW found it high time for a return trip to Finland to catch up with Mrs. Musch and many and varied projects.

Breakthrough in 3D printing 316L

Ground-breaking research into the 3D printing of 316L stainless steel has provided valuable insights into how to control the mechanical properties of 3D printed materials.

1st AM oil & gas part certified by Lloyd’s

The certification by Lloyd’s Register of an additively manufactured pipeline manifold component for the oil & gas industry is an industry milestone.
INTERMETALLIC PHASE

Superduplex microstructure’s effect on hydrogen embrittlement susceptibility

Oil and gas companies and duplex manufacturers and suppliers recently defined quality control testing for the purposes of the new ISO 17781 standard. One of the key focuses was how to detect infrequent residual intermetallic phases in segregated areas for the superduplex. Aperam contributed to the discussions by conducting a number of experiments that quantified the microstructure’s effect on an offshore application’s susceptibility to hydrogen embrittlement.

ADDITIVE MANUFACTURING

Nitrogen vs argon atomisation of 17-4 PH stainless steel and its effects on AM processing

The choice of atomising gas on the properties of metal powders, in conjunction with the specific additive manufacturing process parameters, plays a key role in the ultimate microstructure and mechanical properties of fabricated parts as demonstrated in this Selective Laser Melting study.

MARKET OUTLOOK

Stainless Europe: the EU bounces back

Rumours of the death of the European Union and of its currency, the Euro, have been greatly exaggerated. After a tough decade the region is finding its feet again and experiencing strong growth. Its stainless steel industry likewise suffered but is recovering slowly. To survive, EU producers must invest in R&D and compete in a global market. Your intrepid correspondent overheard the following conversation during a recent conference, late at night, in the bar.

WELDING

Shielding gas and purging techniques during welding Part 4: Minimising O₂ and use of monitoring equipment

In parts 1-3 the author outlined the problems in selecting the optimum purge gas and technique as well as protective enclosures and trailing shields. In this final article he explains that using specialised weld purging equipment does not guarantee defect free welds; controlling the oxygen content of the purge gas is crucial to success.
Nippon Yakin Kogyo Received NORSOK Certification

NORSOK M-650 ED.4
NORSOK M-630 ED.6
MDS D45 (S31803, S32205) REV.5
MDS D55 (S32750, S32760) REV.5
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New registration of S32760 in November 2016

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An experienced, enthusiastic, innovative manager (MEng.) with an extensive knowledge of cold and hot forming, forging, and the welding of all type of steels/alloys/metals, is searching for a new challenge/opportunity.

He has a demonstrated history in industrial engineering as a Technical and Managerial Director. Further, he enjoys training engineers and craftsmen to improve quality. A strong mechanical engineering professional with expertise in materials, metallurgy, welding, and many other aspects of production, he also has experience with products from almost every industry: from food to aerospace, from wind energy to nuclear power, and from oil & gas to petrochemicals. He has performed an extensive amount of research during his career. Though his home base is in The Netherlands he has also worked in Belgium, Germany, Saudi Arabia, Romania, the US, and Mexico. He is used to greenfield projects, from a complete production plant in Saudi Arabia (his biggest achievement) to production lines and machines. All projects included training the personnel. The type of work association he is looking for is based on long-term projects but he is also prepared to accept short-term ones. He is willing to work world-wide and speaks and writes fluently in Dutch, English, and German.

PROFILE

• Very good analytical skills;
• Innovative, quality driven;
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• Team player, but can work very well independently as well;
• Focused and determined in the attainment of goals.

If you would like to contact this person then please send us a message at: jobapplication@kci-world.com.

Kristian Røkke is new Aker CIO

Aker ASA has appointed Kristian Røkke as its Chief Investment Officer (CIO) effective 1 January 2018.

Mr. Røkke is currently the CEO of Akastor ASA (Akastor), a publicly listed oil service investment company, and will be succeeded by Karl Erik Kjelstad from 1 January 2018. Aker will propose to the nomination committee of Akastor that Kristian Røkke assume the position as Chairman of the Board of Akastor from the next Annual General Meeting.

New chairperson for Nickel Institute

At the Annual Members Meeting of the Nickel Institute on 2 November 2017, Anton Berlin, Director of Marketing, MMC Norilsk Nickel (Nornickel) was elected Chairperson of the Nickel Institute. His appointment is for a one year term, renewable for a second year. Scott Yarrow, VP, Glencore International AG was elected first vice chairperson.

Mr. Berlin succeeds Martin Vydra, senior VP, Commercial and Technologies, Sherritt International.

MDL to focus in the Americas

Maritime Developments has strengthened its sales force with the appointment of Andrew Blaquiere as VP – MDL Americas.

Blaquiere joins MDL from a flex-lay equipment rental supplier where he held various positions including business development manager and proposal/project manager. He joins Mark Williamson, President – MDL Americas, in Houston to support the company’s continued growth in the offshore Americas market.

Maciej Gwozdz president at Outokumpu

Maciej (Mac) Gwozdz has been appointed President of Business Area Europe as of January 1, 2018. Mac joined Outokumpu in 2016 as executive VP for Operations, Europe. In his new position, he will continue as a member of the Outokumpu Leadership Team and report to CEO Roeland Baan.

BASF announces succession

Effective at the end of the Annual Shareholders’ Meeting on May 4, 2018, Dr. Martin Brudermüller, currently vice chairman of the Board of Executive Directors, will become Chairman of the Board of Executive Directors of BASF SE. Brudermüller will succeed Dr. Kurt Bock, who is BASF’s Chairman since 2011 and has been a member of the Board of Executive Directors since 2003. This change will allow Bock to be elected as a member and chair of BASF’s Supervisory Board in 2020 after the end of the statutory two-years cooling-off period.

Dr. Hans-Ulrich Engel was appointed as new vice chairman of the Board of Executive Directors. Furthermore, the Supervisory Board extended the appointments of Brudermüller, Engel and Sanjeev Gandhi to the Board of Executive Directors by five years until the Annual Shareholders’ Meeting 2023. In the course of the changes, the number of Board members will be reduced from eight to seven in May 2018.
Subsea 7 announces a change

Subsea 7 S.A. (SUBC, SUBCY) has announced a change to its Executive Management Team, which will take effect on 1 January 2018. Øyvind Mikaelsen has decided to step down from his role as executive VP Commercial and will be leaving Subsea 7 in the Q2 2018. Mr. Mikaelsen will be succeeded on 1 January 2018 by Stuart Fitzgerald who will be appointed as executive VP– Strategy and Commercial and will be a member of the Executive Management Team. Stuart, who is currently the VP for Strategy and Technology, will assume responsibility for the commercial activities of the SURF and Conventional Business Unit as well as Asset Development, Sales and Marketing, Strategy and Technology, and the Alliances.

Kloeckner’s Bill Partalis steps down

In December 2017, Bill Partalis stepped down after serving for 18 years as CEO of Kloeckner Metals Corporation. He has served the company for 34 years and has directed the company through many changes and growth. On the day of Mr. Partalis’ retirement, his contribution as a team player and a manager was appreciated by many of his colleagues.

Richard Matheson Nickel Institute director

Richard Matheson has been promoted to director, market development, Nickel Institute with immediate effect. Richard succeeds Nigel Ward who retired from the Nickel Institute on 31 December 2017. In his new role, Matheson will continue to develop the markets for nickel and takes over as the global lead for the Nickel Institute’s Market Development team. He is also now a member of the Nickel Institute’s Management Committee.

Alex Dimitrief is senior VP at GGO

GE has announced that Alex Dimitrief, general counsel for GE, has been named the new senior VP, President & CEO for the Global Growth Organization (GGO) reporting to GE Chairman and CEO John Flannery. Dimitrief joined GE in 2007 after more than 20 years as a trial lawyer in Chicago and New York. He will continue to also serve as the General Counsel for GE until his replacement is named.
Industries Update

**Guild International employee purchase**

Guild International, specialist in coil joining equipment for the steel processing, tube producing and stamping industries, has announced new ownership with the purchase of the company by three long-term employees: Joseph “Joe” Thomas, formally VP of Operations, has been named President; William “Bill” Maruschak will continue as Chief Financial Officer; and Mark Wagner, formally Sales Engineer, has been named Vice President of Sales. Mr. Thomas and Mr. Maruschak have each been with the company for over 30 years, while Mr. Wagner joined the company in 2009.

Guild International is a privately-held company that has been owned by Michael Wheeler, son of Donald Wheeler, the original founder of the company. Mike Wheeler will continue on as Chairman of the Board. Guild International was established in 1958, making 2018 its 60th year in business. The company holds many patents for their coil joining processes and equipment. Throughout the years, Guild International has designed and built thousands of installations around the world on virtually all types of coil processing lines.

“As a longtime employee, I’ve always known that Guild International was a solid, stable company that built great machines,” says Mr. Thomas. “When the opportunity was presented to purchase the company from Mike, with Bill and Mark as my partners, I knew this would be a chance of a lifetime. Now Bill, Mark and myself have the opportunity to take Guild into the future, built on a solid reputation of 60 years serving many industries.”

**SUBC awarded offshore contract**

Subsea 7 S.A. (SUBC) announced the award of a substantial contract from Aker BP on behalf of the Ærfugl Unit for the Ærfugl gas field development, located approximately 210 km west of Sandnessjøen in the Norwegian Sea. The contract includes an option for the Ærfugl Phase 2 scope, which may be exercised by Aker BP in the future.

This EPCI contract is a long-distance tie-back involving the application of Subsea 7’s Electrically Heat Traced Flowline (EHTF) technology for the 21 km tie-back to the Skarv FPSO. Project management and engineering will commence immediately at Subsea 7’s offices in Stavanger, Norway. Fabrication of the EHTF system will take place at Subsea 7’s spoolbase at Vigra, Norway and offshore operations will take place in 2019 and 2020.

**BUTTING takes over Sosta**

BUTTING Group has taken over the operation of Sosta GmbH & Co. KG in Kønnern near Halle. The new company has been entered in the Commercial Register as Sosta stainless pipes GmbH.

With the purchase and transfer agreement of 5 October 2017, Sosta stainless pipes GmbH acquired all the material and immaterial assets of Sosta GmbH & Co. KG for business and production operations on the Kønnern site. Sosta stainless pipes GmbH is now entered in the Commercial Register of the Stendal District Court. The entry in the Commercial Register explicitly states that liabilities of the seller have not been acquired or transferred and these have also not been taken over by Sosta stainless pipes GmbH. The same applies to Sosta B.V. in the Netherlands.

**Nano-scale spikes kill bacteria**

By using an electrochemical etching process on a common stainless steel alloy, researchers have created a nanotextured surface that kills bacteria while not harming mammalian cells. If additional research supports early test results, this process might be used to attack microbial contamination on implantable medical devices and on food processing equipment made with the metal. While the specific mechanism by which the nanotextured material kills bacteria requires further study, the researchers believe that tiny spikes and other nano-protrusions created on the surface puncture bacterial membranes to kill the bugs. The surface structures don’t appear to have a similar effect on mammalian cells, which are an order of magnitude larger than the bacteria. Beyond the anti-bacterial effects, the nano-texturing also appears to improve corrosion resistance. The research was reported in a paper in ACS Biomaterials Science & Engineering by researchers at the Georgia Institute of Technology.

Julie Champion, an associate professor in Georgia Tech’s School of Chemical and Biomolecular Engineering, said: “A lot of the antimicrobial approaches currently being used add some sort of surface film, which can wear off. Because we are actually modifying the steel itself, that should be a permanent change to the material.”
**Nickel-based super alloys for sour wells**

The new face of oil and gas discovery will be with deep wells. As compared to shallow wells, deep wells normally need high performance nickel based alloys. Wells are classified as sweet or sour. Sweet wells are just mildly corrosive, whilst sour wells are extremely corrosive. Material selection is particularly critical for sour gas wells. The chosen material should be corrosion resistant, economically priced, reliable and have suitable strength for the wells. In the severe conditions, material selection varies from carbon steels for sweet wells to duplex stainless steel to Incoloy 825 for sour well service. Age hardened nickel base alloys and cold processed solid solution nickel base alloys offer several advantages like high strength, toughness and low magnetic permeability and outstanding corrosion resistance. Properties of Inconel bars are ideal to be chosen for service in the well conditions. Material choice for down-hole and wellhead components like hangers, safety valves, pumps and packers demand age hardenable alloys to receive essential strength in heavier cross-section. Nickel alloys widely used in these applications are: Inconel 718, Inconel X750, and Monel K-500.

**BIBUS acquires majority of S + D Spezialstahl**

BIBUS HOLDING AG, a 70-year-old, owner-managed, Swiss-based and internationally oriented trading and service company, will take over S + D Spezialstahl GmbH, with headquarters in Stelle near Hamburg, effective retroactively from 1st July 2017. S + D Spezialstahl GmbH, founded in 1997, is a leading European stock holder of materials such as titanium and titanium alloys, nickel and nickel-based alloys plus special stainless steels for applications in industries including aviation, automotive, medical and chemical. The company has extensive service centre operations employing 35 people in Germany, France, Italy, the Czech Republic as well as in the UK. The company will be led by Olaf Schenk, founder and minority partner, and Uwe Friebenstäuber, Managing Director. The BIBUS METALS Group, part of BIBUS HOLDING AG is enhanced by S + D Spezialstahl GmbH. There are small overlaps on mutual stock programmes, customers and supplier relationships. The management of both companies is convinced that, due to the very close relationship, a significant benefit for customers will be generated. The BIBUS Group was founded in 1947 by Dipl. Ing. Hans Bibus and is today led in its third generation by Christian Bibus and Dr. Conrad Ulrich-Bibus. Approximately 1,100 persons are employed in more than 50 subsidiaries over more than 30 countries in Europe and Asia.

**Bechtel PIM tool bags an award**

Bechtel has been awarded the prestigious 2018 Digital Edge 50 Award in recognition of its new Pipeline Integrity Management (PIM) tool. With support from Bechtel’s Future Fund, an internal incubator which finances development of disruptive technologies, innovators from the Bechtel pipeline business designed the tool to help customers prioritize critical pipeline integrity work and improve overall safety. The tool integrates pipeline data, Geographic Information Systems (GIS) and data-science modelling to help customers improve their forecast maintenance and replacement of pipeline systems.

Bechtel began development of the PIM tool after it was recognized that customers needed support in establishing new standards of pipeline safety across the world. The tool utilizes massive geospatial data sets and proprietary algorithms, creating detailed risk assessments based on over 100 parameters and relationships known to contribute to pipeline failures. This data is then used to assess the impact of incremental changes in material, construction and geospatial characteristics along the length of the pipeline. Utilizing Bechtel’s Big Data & Analytics Center, the PIM tool can analyze hundreds of thousands of welds and pipe joints in a matter of minutes, providing valuable assessments of a customer’s pipeline system in record time.

**voestalpine installs heat treatment line**

voestalpine Tubulars GmbH & Co KG based in Kindberg-Aumühl, Styria, Austria, has successfully commissioned a new heat treatment line and a hot tube straightening machine supplied by SMS group. The line is designed for seamless tubes with outside diameters between 60.3 and 273.0 millimeters. It can process steel grades with alloying contents of up to approx. 20 percent.

The heat treatment line supplied by SMS group consists of a walking beam type austenitizing furnace, an SMS Quenching Head, a cooling table for normalizing, a tempering furnace, also of walking beam design, a cooling bed and two sawing stations for sample cutting. This equipment allows voestalpine Tubulars to perform various different heat treatments such as quenching, tempering, and normalizing in one single line. The heat treatment line can handle tubes with wall thicknesses of up to 25 millimeters. The line is designed to be expanded by an additional quenching unit at a later stage in order to process tubes with wall thicknesses greater than 30 millimeters.
Researchers at Fraunhofer IPA have developed a procedure for internally cooling disc-shaped, rotating cutting tools. With the support of pertinent mechanical saw and sawing tool manufacturers, the result is a lightweight, upgradable and cost-effective concept that represents a milestone in the evolution of circular saws.

When cutting materials, the temperatures rise, which negatively affects the workpiece and shortens the tool’s service life. One possibility for directing the cooling lubricant at the cutting area is internal cooling within the tool, which sees the cooling lubricant directed through internal channels in the tool directly to the cutting area.

Now, for the first time, Fraunhofer IPA has been able to integrate channels into the saw blade, meaning that internally cooled tools can be created. The idea to adapt internal tool cooling systems to include disc-shaped tools such as circular saw blades has enormous potential and has met with a great deal of interest in the industry.

Teledyne TSS builds small subsea tracker

Teledyne TSS, a division of Teledyne Marine, announces the expansion of its market leading range of subsea pipe and cable detection and tracking products with the launch of the new smaller HydroPACT 660 pipe tracking system. The 660 has been designed to help reduce the cost of subsea pipe surveys by allowing the use of smaller classes of underwater remotely operated vehicles (ROVs). In addition, TSS is also expanding the capabilities of its larger HydroPACT 440 pipe tracking system by introducing a new 24VDC upgrade kit.

The new, compact HydroPACT 660 sports a single small form factor coil array measuring 1,200mm x 600mm at a weight of only 15.8kg that offers an operating range of greater than 85% of that of the significantly larger HydroPACT 440 system. This smaller and lighter coil array suits smaller ROVs such as observation class or inspection class.

The HydroPACT 660 operates to 3,000m depth, and is offered with two different power options: 24VDC or 110VAC. Teledyne TSS has introduced a new 24VDC power supply pod for the HydroPACT440 system. This will help to increase the flexibility and use of the system on vehicles that only support DC power capability.
Metalcraft in Top 100 apprenticeship employers

Stainless Metalcraft, which manufactures components for the energy, nuclear and medical technology sectors, has been named in the Top 100 Apprenticeship Employers for the second consecutive year. The GBP 16 million turnover business, which is based in Chatteris, has a 155 strong workforce. Over 50% of Metalcraft’s employees have been apprentice-trained; of these, over 90% have been trained by the company. Austen Adams, managing director of Stainless Metalcraft, said: “Gaining this national recognition endorses our long-term commitment to apprenticeships. What is also impressive is the fact that we are an SME. To be sitting alongside some very big hitters in the Top 100 shows we are proudly punching above our weight in terms of size. It highlights our pedigree when it comes to investing in apprenticeships.”

He added: “2018 is the Year of Engineering so it’s a great start to the year to be named for the second year in a row in the Top 100. Engineering is an exciting and entrepreneurial industry to work in, and one which makes a vital contribution to the economy in terms of jobs, investment and wealth creation. Collectively we need to ensure we shoulder responsibility to train up and inspire the next generation of engineers to address skills shortages.

Being in the Top 100 is an acknowledgement of the hard work of the team, and the high quality of our four-year apprenticeship programme.”

Martin Lawrence, Commercial Director, added: “We continue to operate in very competitive domestic and international markets, and to ensure we continue to be a fit and efficient business, we need a pipeline of apprentices. That’s why we remain committed to recruiting up to 10 new apprentices a year until at least 2020. Our ambition is to grow more than three times our current turnover and they are key to helping us achieve this.”

Metalcraft is currently recruiting for the next generation of apprentices, due to start with the company in September this year. For further information, visit www.metalcraft.co.uk/careers/apprenticeships/.

JX Nippon to work at Beryl gas field

JX Nippon Oil & Gas Exploration Corporation has announced that PETROLIUM NASIONAL BERHAD (PETRONAS), the national oil company of Malaysia, has agreed to provide JX Nippon Oil & Gas Exploration (Malaysia) the oil and gas rights of Beryl Gas Field (Beryl), and approved the Field Development Plan (FDP) for Beryl on 27th October 2017. Beryl, an already discovered but undeveloped gas field, lies in the shallower zone in the same location as the underlying Helang Gas Field (Helang) and Layang Oil and Gas Field (Layang) in Block SK10, Offshore Sarawak, for which NOMA has been conducting production operation as operator.

The peak production of natural gas from Beryl is estimated to be around 140MMscf/d. The produced gas from Beryl, together with natural gas from Helang and Layang, will be supplied through subsea pipelines to the MLNG Tiga Sdn. Bhd. liquefaction plant in Bintulu, Sarawak. The natural gas will be sold as LNG after liquefaction to its customers, including buyers in Japan.

McDermott bags an EPCC contract

McDermott International, Inc. (MDR) has announced a substantial contract award from Maersk Olie og Gas A/S (Maersk Oil) for engineering, procurement, construction and commissioning (EPCC) services for the Tyra Redevelopment project, located offshore in the Danish sector of the North Sea.

McDermott will provide engineering, procurement and construction for two separate work packages for Maersk Oil under the redevelopment project. With a combined weight of all structures provided by McDermott at nearly 32,000 tons (29,000 metric tons), the scope of work represents one of the largest combined projects for McDermott in the North Sea.

McDermott plans to perform project management, engineering and supply chain management from its office in Kuala Lumpur, Malaysia and will fabricate and assemble the structures at its fabrication yard at Batam Island, Indonesia.

McDermott is scheduled to complete its work packages for sail-away by February 1, 2020 and February 1, 2021.

Saipem signs contracts worth $380 M

Saipem has signed a contract with Eni Angola S.p.A. in relation to the West Hub Development project in Angola, which incorporates the work orders previously assigned and communicated in 2016 and 2017 and adds the scope of work for the development of the Vandumbu field in Block 15/06. The additional activities will be carried out by the Offshore E&C division and encompass the engineering, procurement, construction and installation required for the development of the Vandumbu subsea field at deepwater. Overall the project includes the realisation of two production pipelines made of special material, and the laying of umbilicals and service lines of various diameters.

Saipem has been awarded a new contract in the Gulf of Mexico involving the Transportation & Installation of the compression platform CA-KU-A1 on behalf of Dragados Offshore de Mexico S.A. de C.V. (DOMSA). Operations will be carried out by the semi-submersible vessel Saipem 7000. In the Arabian Gulf, Saipem will carry out drilling activities for the National Drilling Company (NDC) using the high specs jack-up Perro Negro 8 for a period of ten months beginning in late 2017. The combined value of the above contracts is approximately USD 380M.
NSSMC increases capacity, prices

Nippon Steel and Sumitomo Metal Corps main production mills for seamless stainless steel pipes - Amagasaki factory and Oita Works/Hikari Area - are now operating at full capacity. In addition to orders from clients such as stockists and reroll piping manufactures, NSSMC received orders exceeding production capacity for FY2018 by end of the third quarter of 2017. Due to selective order acceptance and production increases, various costs such as personnel and distribution expenses have risen. To maintain stable supply NSSMC has already increased prices by about 10%. Although demand recovery is on the way, the demand for CRA pipes for oil and gas has increased due to resumption of oil and gas field development.

Ormat secures USD 50M EPC contract

Ormat Technologies Inc. (ORA) has announced that one of its subsidiaries has signed approximately USD 50M Engineering, Procurement and Construction, (EPC) contract, with TOP ENERGY Ltd for Ngawha extension geothermal project located in Ngawha, New Zealand. The project is expected to be completed in the Q1 2021.

Under the EPC contract, Ormat will provide its air-cooled Ormat Energy Converters for the Ngawha geothermal extension project. This is the third EPC contract Ormat has signed with TOP ENERGY Ltd. The first one was for the Ngawha I power plant in 1998 and the second for Ngawha II power plant in 2008.

ULT AG introduces new conductive system

ULT AG has introduced a conductive version to its device series LAS 260. The new system is ideally suited for extraction and filtration tasks in processing materials that may generate easily inflammable or explosive dust/air mixtures, such as titanium. These gas mixtures mean special challenges for capture and filtration. A specifically developed device and filter concept was required to prevent additional ignition sources within the fume extraction system. Within the new LAS 260, both filter modules (F9, H14) are grounded. In addition, the electronic components have been specially designed and integrated. The LAS 260 extraction and filtration system was developed for the removal of airborne pollutants occurring in material processing by means of laser or welding technologies. Its mobile and versatile system concept allows the new LAS 260 to be utilized at changing working stations. Furthermore, it is suited for applications in production lines.
Within AMETEK Specialty Metal Products (SMP), Reading Alloys and AMETEK SMP Eighty Four are the master alloy and metal powders specialists. Despite some industrywide challenges on the horizon, including slower growth in steel demand worldwide, both businesses look to 2018 as a year of opportunities, and both will showcase their expertise in master alloys and high-purity powders that meet the most-stringent metallurgical demands at two key events in February 2018.

At Titanium Asia 2018 in Singapore Reading Alloys will exhibit its latest product range in Kiosk 4 and present a conference paper on market trends for key titanium raw materials. Later in February, the International Conference on Powder Metallurgy & Particulate Materials and Exhibition in Mumbai will attract powder metals professionals from both industry and academia. Both businesses plan to exhibit in Stand 4.

Reading Alloys manufactures master alloys and highly engineered titanium metal powders for the aerospace, medical implant, military and electronic markets. In addition to supplying more than 60 standard alloy formulations in a wide range of sizes, Reading can engineer products to individual customer requirements.

New JV for meltless Ti alloy powder

Allegheny Technologies Inc., has undertaken a joint venture (JV) with GE Aviation for the development of a new meltless titanium alloy powder manufacturing technology. The JV includes the construction of a new R&D pilot production facility to produce titanium alloy powders for use in additive manufacturing applications, including 3D printing.

The joint venture will leverage ATI's technology and manufacturing expertise in the production of specialty metal powders and premium-quality titanium and nickel-based alloys for critical and technically advanced applications. The JV will also draw upon GE Aviation’s engineering and development capabilities and technical knowledge of the use of alloyed titanium powders.

ARCEO’s innovative coil coating

As part of its commitment to bringing added-value generation to its customers, specialty coil coater ARCEO ENGINEERING has recently developed, in collaboration with MICROBAN laboratory, a new functionality for producing bio-enhanced coatings. This new functionality, called BIOCLEAN, features anti-bacterial agents which can be integrated in conventional coatings. Because bacteria can be found everywhere surviving as biofilms on solid surfaces, BIOCLEAN was designed to help provide protection against the spread of infection caused by direct contact of surfaces that are exposed either in public facilities or multiple-user-environments. BIOCLEAN is available on various existing indoor coatings commercialized by ARCEO ENGINEERING, for example ArenTouch or ArenNano Black. Other indoor coatings can also be envisaged. The coatings are available in various substrate thicknesses and widths. ArenTouch BioClean or ArenNano Black BioClean help reduce surface bacteria by more than 99% and improve the health environment of a large spectrum of end-users.

ARCEO ENGINEERING has also developed coatings to reduce energy loss. SHIELDARCEO is composed of a nanometric layer of pure aluminium applied by vacuum technology. It performs as a heat shield providing high reflectivity in the infrared and visible energy spectra and is capable of reducing energy loss by 80%. It is available either on stainless steel or flat carbon steel, provides excellent corrosion resistance with good formability and is useful wherever the need for high reflectivity combined with great mechanical properties and durability is required. On stainless steel, SHIELDARCEO preserves the aesthetical aspect of this material under high temperature (up to 600°C).

Siemens uses AM for gas turbines

Additive manufacturing (AM) has the potential to become a new key technology. For example it opens up new attractive prospects in the manufacture of gas turbines. This is why Siemens has been investing in this technology right from its inception, and is now driving the industrialization and commercialization of these processes. Siemens already uses the technology for rapid prototyping. Furthermore the company is now developing solutions ready for series-production for manufacturing gas turbine burner nozzles and repairing burner heads. Just recently Siemens achieved yet another breakthrough: the first gas turbine blades ever to be produced using Additive Manufacturing have successfully finished performance testing under full-load conditions.
NSSC to launch new product

Nippon Steel & Sumikin Stainless Steel Corporation (NSSC) will launch NSSC FW 0 to the domestic market as a new product of the FW (Forward) series which are proprietary products of tin-doped high purity ferritic stainless steel. The FW series are Sn-doped high purity ferritic stainless steel, based on a revolutionary new technology that dramatically improves the corrosion resistance of ferritic (chromium) stainless steel by adding a trace amount of tin. It also reduces the amount of chromium (Cr), a basic element of stainless steel, and realizes improved workability. The FW series products achieve superior steel type characteristics, despite not adding nickel and molybdenum, while reducing the Cr content. Each product (NSSC® FW1, NSSC® FW2) of the FW series has a product concept of “resource saving, eco friendly and high price stability” as corroborated by our customers, and we have achieved 30,000 tons orders annually. NSSCFW 0 (13Cr - Sn) further develops our proprietary seeds technology cultivated with NSSCFW1 and NSSCFW2, while lowering the cost by reducing the content of Cr to 13%, which is almost the same as SUS 430, but it realizes corrosion resistance while achieving high workability and excellent weldability in line with SUS 304. FW 0, for example in the electric products field, has already been adopted as a high function and cost saving material in the overseas market, but NSSC aim to expand the base of the stainless steel market, and will now fully launch it to the domestic market. In order to provide valuable products to our customers, through the diffusion of stainless steel, which is the basic material, NSSC will continue to enhance the lineup of the FW series, which are resource-saving general-purpose steel grades, and contribute to the customers’ solution to meet their various needs.

New hybrid material for hip implants

Around the year 2020, the number of hip prostheses around the world is expected to rise to 2.5 million a year. Using the current technology, about 10% of these implants will no longer be firmly fixed 10 years after surgery. This inspired TU Delft Professor Amir Zadpoor to find a means of preventing implant loosening. Meta-biomaterials are the biomedical variant of so-called metamaterials that display rare characteristics; they are invisible, strong yet lightweight, or display negative thermal expansion. In their publication, Zadpoor and his colleagues outline how these unusual characteristics have immense potential in the development of medical implants. The researchers suspect that a hybrid prosthesis made of both meta-biomaterials with a positive Poisson’s ratio and meta-biomaterials with a negative Poisson’s ratio, will become much more fixed in the body. This will significantly improve the chances of bone growth onto the hybrid meta-biomaterials, securing the implant in place. Zadpoor also thinks that he will be able to use this new material in the future to address the most significant cause of implant loosening.

Infinity Electrostatics’ new technology

Infinity Electrostatics LLC, a technology development firm for additive 3D printing and graphene production, has developed a unique process to track materials. Using graphene, almost any carbon-based material, can be used to make a identifiable carbon fingerprint. The crypto carbon blockchain technology gives a competitive advantage in the market, by having a market identifiable history from inception. It is the new crypto carbon of industry. In a distributed material chain, it provides a mechanism of accountability using a carbon DNA fingerprint which can’t be erased. Using this material in consumer products from clothes to phones, can allow sensors to determine and quantify data of origin (real versus knock-offs), use, and consumer metrics. When a crypto carbon sensor is connected to a network, it can give real-time channel specific traffic data to the factory on product robustness, and tampering. Since the crypto carbon is invisible to the eye, it provides a transparent barcode. Carbon based graphene is also conductive, so it can also be used as a RFID (radio frequency identification). Since crypto carbon can be statically charged, a RFID can be self-powered.

CE mark for K2M Group

K2M Group Holdings, Inc. (KTWO) has received a CE Mark for its CAPRI® Cervical 3D Expandable Corpectomy Cage System featuring Lamellar 3D Titanium Technology™, and the successful completion of its first surgical case. CAPRI Cervical 3D Expandable is the world’s first and only 3D-printed expandable device on the market to facilitate continuous in-situ height expansion and endplate angulation in the cervical spine. The CAPRI Cervical 3D Expandable Cage System stabilizes the cervical spine in cases of vertebral body resections resulting from trauma or tumor. Offered in various footprint options, its continuous in-situ adjustment capabilities allow surgeons to lock the cage with set screws at desired heights and lordotic angles within the expansion range of the implant. The system also allows for fixed endplate angulation of 0°, 5°, and 10° to accommodate surgeon preference and vertebral anatomy. K2M’s Lamellar 3D Titanium Technology uses an advanced 3D printing method to create structures that are impossible with traditional manufacturing techniques. Starting with a titanium powder, the CAPRI Cervical 3D Expandable Corpectomy Cages are grown through the selective application of a high-energy laser beam, incorporating complex internal geometries and rough surface architecture that is associated with bone growth activity.
### Metals in the Future 2018

**19 March 2018 - 20 March 2018**

A new event exploring the long term impact of green technology on metals supply and demand. The conference examines a broad spectrum of materials including steel, aluminium, base metals, minor metals and ferroalloys.

**Location:** London  
**Contact:** Jaelin Bates  
**Phone:** +44 (0)20 7903-2444  
**Email:** conferences@crugroup.com  
**Website:** [http://www.metalstinhuture/home](http://www.metalstinhuture/home)

### Wire & Tube 2018

**16 April 2018 - 20 April 2018**

The combined event, Wire 2018 and Tube 2018. At Wire 2018 the wire and cable industry is focusing its attention on the Rhineland. The world’s biggest and most important forum of the industry's experts will again be presenting itself in Düsseldorf as the hub of the trade. At Tube 2018 meet your business partners at the the world’s most important trade fair for the tube and tube processing industry. Business is conducted here; valuable contacts are made and cultivated and you will also see the global innovations that everyone will be talking about tomorrow.

**Location:** Düsseldorf, Germany  
**Website:** [www.tube-tradefair.com](http://www.tube-tradefair.com)

### Achema

**11 June 2018 - 15 June 2018**

World forum and leading trade show for the chemical engineering and process industry, held every 3 years, in June. The event offers an Innovations Platform and Technology Summit and provides a trend setting meeting point, a take off for investment decisions and an international network of experts and executives.

**Location:** Frankfurt am Main, Germany  
**Contact:** Bianca Bukatschek  
**Phone:** +49 69 7564-198  
**Fax:** +49 69 7564-450  
**Email:** bukatschek[at]achema.de  
**Website:** [www.achema.de](http://www.achema.de)

### Gastech 2018

**17 September 2018 - 20 September 2018**

This event hosts the world’s major NOCs and IOCs as well as companies from across the upstream, midstream, and downstream sectors of the global energy value chain. This event aims to provide opportunities to conduct business transactions, knowledge exchange and global exposure.

**Location:** Fira Gran Via, Barcelona, Spain  
**Contact:** Damian Howard  
**Phone:** +44 (0) 203 615 5914  
**Email:** info@gastechevent.com, damianhoward@dmevents.com  
**Website:** [http://www.gastechevent.com/](http://www.gastechevent.com/)

### 13 June 2018 - 15 June 2018

**The 7th International Congress on Science and Technology of Steelmaking (ICS2018)**

ICS is a forum for researchers and manufacturers involved in the scientific and technical developments of steelmaking. This meeting is aimed at creating an opportunity for a technical exchange at an international level among the numerous experts involved in the steelmaking industry.

**Location:** Venice, Italy  
**Phone:** +39.02.76021132  
**Fax:** +39.02.76020551  
**Email:** aim@aimnet.it  

### 24 June 2018 - 28 June 2018

**Power & Energy Conference & Exhibition**

P&E focuses on the power industry’s latest research, technical advances, development trends, and business strategies, including power plant operations, maintenance, performance, economics, regulatory compliance, and construction presented by a broad range of qualified power professionals.

**Location:** Disney’s Contemporary Resort, Florida, USA  
**Contact:** Stephen Crane  
**Phone:** +1.212.591.8258  
**Email:** cranes[at]asme.org  
**Website:** [http://www.asme.org/events/power-energy/about/contact-us](http://www.asme.org/events/power-energy/about/contact-us)

### 9 August 2018 - 10 August 2018

**International Conference and Expo on Oil and Gas**

Oil Gas Expo 2018 provides a platform for researcher scholars, scientists and academic people to share and globalize their research work while the participants from industry/business sectors can promote their products thus facilitating dissemination of knowledge.

**Location:** Madrid, Spain  
**Email:** petroleum[at]oilgasconferences.org  
**Website:** [http://oil-gas.conferenceseries.com/](http://oil-gas.conferenceseries.com/)

### 13 November 2018 - 14 November 2018

**Managing Aging Plants USA 2018**

The Materials Technology Institute (MTI) and Stainless Steel World Americas will present the 2018 Managing Aging Plants USA Conference & Exhibition, at the Royal Sonesta Houston Galleria in Houston, Texas. The conference program will feature topics related to aging infrastructure as well as stainless steel– and corrosion resistant alloy (CRA)–related subjects like welding, non-destructive testing, duplex corrosion, etc.

**Location:** Houston, USA  
**Contact:** Josh Gillen  
**Phone:** +1-416-361-7030  
**Email:** j.gillen@kci-world.com  

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**Keep up to date with upcoming industry related events... visit the Stainless Steel World calendar page.**
WHEN CONDITIONS HEAT UP
DON’T LET CORROSION SHUT YOU DOWN

Whether it’s higher temperatures, rising pressures or more acidic media, conditions in oil refineries have never been more extreme. Tube and pipe corrosion are a constant threat, causing as many as half of all major shutdowns. This is why hundreds of the world’s most demanding petrochemicals refiners are turning to the next generation of corrosion resistant alloys. Like one German oil refinery, which used Sandvik SAF 2707 HD hyper-duplex heat exchanger tubes to reduce the number of shutdowns from 8 to 1 over a period of four years. The result was massive savings on material replacement. So as your tubes’ performance is pushed to new heights, find out how we can help keep corrosion from shutting you down.

SMT.SANDVIK.COM
The use of mechanically lined pipes represents an economically interesting solution in all areas where high pressures and aggressiveness can be found in the media transported. BUTTING is one of the pioneers of this technology and today exports its clad piping products around the world for some of the most demanding and sensitive applications in the oil and gas industry. Stainless Steel World spoke to Managing Director Thomas Schüller about several exciting and unique developments in the company’s product offering; glued mechanically lined pipes, a special mechanically lined pipe and clad pipes with upset ends.

By Joanne McIntyre

At the beginning of the 1990s, BUTTING developed the mechanically lined BUTTING-Bimetal-pipe (BuBi® pipe). With the BuBi® pipe, a longitudinally welded BUTTING pipe made from stainless steel or a nickel based alloy is telescopically aligned inside a carbon-manganese steel pipe and mechanically connected by means of a hydro-forming process. This combination allows the very good strength and toughness properties of carbon-manganese steels to be linked with the high corrosion resistance of stainless steels or nickel-based alloys.

For many years BuBi® pipes have been used successfully for demanding and sensitive purposes in the oil and gas extraction industry, mainly in the offshore area – but in the onshore area as well. Examples of typical applications are pipelines or riser pipes for the transport of oil and gas, SCR pipes, water injection lines or pipes for the transport of waste water. These are laid in many different ways: they are suitable for conventional laying onshore and for offshore laying by S-Lay, J-Lay, bundle or processes. For technical reasons the reel-lay method is, in general, the most cost-effective of these procedures.

The cost of laying and thus the laying method have a major influence on the selection of the pipe type for a project. Today and in future, the focus will be on the cost-effectiveness of laying pipes. That was the basis and motivation for a further product innovation. BUTTING has developed...
a glued mechanically lined product which can be laid by the reel-lay process, without using inner pressure or increasing the wall thickness of the CRA liner: the GluBi® pipe!

Thomas Schüller, Managing Director of BUTTING in Knesebeck, is impressed by the innovation: “We know that the laying process is becoming more and more important when clad pipes are selected. At the moment, reeling is the most cost effective process for laying pipelines and risers. Also, bending of mechanically lined pipes is restricted when reeling. Depending on many factors, such as wall thickness, outside diameter and bending radius, wrinkles may be formed in the liner of a traditional mechanically lined BuBi® pipe. Faced with this problem, we have developed a product innovation that reduces the cost of materials and of pipe-laying.”

Long-standing development work
As early as 2000, BUTTING had the idea of a glued pipe. However, it could not be welded and so the development stopped. In 2009, development work restarted. In 2016, BUTTING was able to present a glued pipe with weldable pipe ends to oil companies and the EPC companies (pipe layers). The principle of the GluBi® pipe is very innovative: the basis is a mechanically lined BuBi® pipe, which is provided with an additional special adhesive between the carbon-manganese steel and the corrosion resistant liner. The choice of adhesive represented a particularly big challenge for BUTTING. In addition to the stringent quality requirements, a number of other conditions applied. The adhesive has to satisfy the following criteria, for example:

- Temperature resistance
- Shear strength
- Flexibility
- Ageing resistance

Wide variety of materials and sizes
There are a number of variants available for the GluBi® pipe – both for the carbon-manganese steel and for the corrosion-resistant liner – and for possible combinations. This variety is based on the materials for BuBi® pipes. An overview of the materials may be obtained from Tables 1 & 2. During the production of GluBi® pipes, very tight tolerances and special quality standards must be complied with. As regards the tolerances, the same requirements can be implemented that have already been achieved successfully with the BuBi® pipes in previous decades.

Reproducible production process
The production process for the GluBi® pipe corresponds to 90% of the production process for the BuBi® pipe. Thus a tried and tested process can be employed and its reproducible quality level is universally recognised. Unlike in production of the BuBi® pipe, with the GluBi® pipe the outside surface of the liner is connected to the inner surface of the carbon-manganese pipe by an adhesive, and the pipe ends are specially prepared for weld overlay welding.
The pipe ends are cladded using the gas metal arc welding (GMAW) process with two layers. Here the same welding procedure specifications (WPS) are used as for BuBi® pipes. The result: the pipe ends of the GluBi® pipes correspond to the ends of the BuBi® pipes. Thus the behaviour of the pipe ends of GluBi® pipes during circumferential welding is absolutely identical to the pipe ends of BuBi® pipes.

**Simulation of the reeling process**
BUTTING is aware that products for the oil and gas industry are subject to the highest quality requirements. Thus as early as 2010, BUTTING developed a test unit to simulate the reeling process and installed it on the site of the main plant in Knesebeck. The test rig makes it possible to simulate many different applications and uses of the pipes. In the past years, a variety of tests were repeatedly performed with GluBi® pipes.

For further trials of the GluBi® pipe’s suitability, the outside surface of test pipes were experimentally coated with plastic: the examination of the liner using a camera produced no evidence of wrinkle formation. The temperature strain did not have a negative influence on the adhesive connection.

**Ready for market**
The first two stages of the qualification process of the GluBi® pipe in accordance with DNV-RP-A203, together with DNV GL, could be completed in the course of the last year. Volker Lahmann, product engineer at BUTTING, adds: “We plan to complete the third stage of the qualification by the end of the second quarter of 2018.” Various tests are still due to be carried out. These include simulations using a finite element model of DNV GL in order to find all factors that may have an impact on the pipe. Later the finite element model shall be used to determine critical factors of different dimensions and material grades at an early stage. Thus it will be possible to define critical temperatures in service and to develop non-destructive testing methods as part of quality assurance, to be able to certify the existence of the adhesive and its performance.

Thomas Schüller draws an initial conclusion: “Customers in the oil and gas industry and EPC companies have reacted very positively to the new product and have shown genuine interest. They wish to receive test pipes for further investigations. We will be ready to comply this request in 2018.”

**Investments in continuous production process**
In order to provide an optimum production process for this product, two new production halls are being built at the main plant in Knesebeck. The layout planning was already available in the middle of last year and immediately after receipt of the building permission, work started in November. It is planned to have the machines and equipment installed during the fourth quarter, 2018. Thomas Schüller: “The new steel equipment is the highlight of our investments: optimum processing of the pipes will be possible, the working conditions of our staff will be improved and our capacities in this production area will be increased considerably at the same time.”

He adds: “The continuous production process for the GluBi® pipes will be set up by the end of 2018. Thus our customers will have production capacities for GluBi® pipes in sizes from 6” to 18”.”

The Managing Director is quite positive that the added value of the GluBi® pipe will convince the customers and that the pipe will establish itself on the market.

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**Table 1. Possible materials for outer pipe**

<table>
<thead>
<tr>
<th>Carbon-manganese steel</th>
<th>Minimum yield strength (MPa)</th>
<th>Minimum tensile strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>API X52</td>
<td>360</td>
<td>460</td>
</tr>
<tr>
<td>API X60</td>
<td>415</td>
<td>520</td>
</tr>
<tr>
<td>API X65</td>
<td>450</td>
<td>535</td>
</tr>
<tr>
<td>API X70</td>
<td>485</td>
<td>570</td>
</tr>
</tbody>
</table>

**Table 2. Possible materials for inner pipe**

<table>
<thead>
<tr>
<th>inner pipe</th>
<th>Minimum yield strength (MPa)</th>
<th>Minimum tensile strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy 825</td>
<td>241</td>
<td>586</td>
</tr>
<tr>
<td>Alloy 625 (Gr 2)</td>
<td>276</td>
<td>690</td>
</tr>
<tr>
<td>904L</td>
<td>220</td>
<td>490</td>
</tr>
<tr>
<td>316L</td>
<td>170</td>
<td>485</td>
</tr>
</tbody>
</table>

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Every pipe is subjected to stringent testing and inspection before delivery.

GluBi® pipe: Simulation of a reeling process; no evidence of liner wrinkling.
Progress by partnership
For a great number of customers worldwide BUTTING is an important partner in the product development process. In January 2018 the qualification of a modified mechanically lined pipe could be completed. Usually, the seamless carbon-manganese steel pipes used for the production of mechanically lined pipes are purchased. For some projects also submerged arc welded carbon-manganese steel pipes were used. BUTTING was addressed by a renowned Norwegian oil and gas company and asked to test a high frequency induction welded carbon-manganese steel pipe for the production of ButBi® pipes which can be used for a new offshore project. The weld quality of the HFW pipe is based on a production procedure from Japan. The toughness values of high frequency induction welded carbon-manganese steel pipes obtained hitherto were insufficient. Thanks to a new procedure and further development very good values could be achieved in those temperature ranges that the pipes are subject to in service.

Thomas Schüller comments: “It is always a pleasure for us to support our customers in innovative processes. Also in case of this specific project it was exciting for us to join the qualification programme of the modified product.”

For the qualification a high frequency induction welded steel pipe in the size 20” and a wall thickness of 22 mm was produced for the first time. Together with the customer an extensive qualification programme was prepared. Thomas Schüller: “After the successful completion we were pleased to note that the HFW welded outer pipes are a third alternative beside the submerged and seamless carbon steel pipes.”

The advantages of this pipe are obvious: less production costs and very good mechanical-technological properties, e. g. low-temperature toughness.

New development: clad pipe and lined pipe with upset ends
In case of offshore pipelines transporting media from deep sea waters, partly very long riser pipelines are necessary to connect the pipe systems at the bottom of the sea to the floating platforms (FPSO = Floating Production Storage and Offloading Unit). They are subjected to very high alternating stresses (vibrations) due to the currents at sea, weather conditions etc. which can vary enormously in some areas of the pipe system. The pipes used in areas where stresses are extremely high require specific design. As the circumferential weld joining individual pipe segments generally is the weakest area in a pipeline riser, special care has to be taken to alleviate the stress potential here.

Sometimes, pipes are used with a higher wall thickness over a defined length at the ends (depending on the design) thus increasing the cross section of the weld. The bigger the cross section of a circumferential weld, the lower the strain. Joachim Banse, product engineer at BUTTING, comments: “The pipes with so-called upset ends are especially used in the touchdown and splash zones.”

In case of solid carbon steel pipelines, such thickened pipe ends are achieved by upsetting the ends in a forging process. As regards metallurgically clad and lined pipes, various options for the production of thickened pipe ends are available.

Various methods
The following options are available now:

a) In some areas of a riser pipeline it is possible to integrate prefabricated pipe segments with higher walls by welding (workshop conditions). However, this method is not allowed for the critical areas of a riser pipeline under enormous stresses.

b) Riser pipes (generally in 12 m lengths) are produced with an increased wall thickness over the full length, followed by subsequent machining to achieve the required geometrical dimensions.

c) Use of riser pipes with higher walls over the entire pipe length from the outset. This option would lead to big weight problems.

d) The riser pipes are thickened at the ends by overlay welding. However this option is not qualified yet.

Qualification programme for a potential solution
Following a suggestion by the welding technology department at BUTTING, an in-house weld overlay solution was developed last year. The weld cladding was performed on the outer surface of the carbon steel pipe. After the first development approaches had been presented to various oil companies and EPC companies, positive responses to the findings were received. The support and encouragement from these companies was reason enough for BUTTING to continue the development work. Production tests with circumferential welds of various types were carried out together with various pipe layers. Joachim Banse comments: “We want to obtain DNV-GL qualification also for this specific product, true to our motto ‘Progress by Tradition’.”

Thomas Schüller adds: “In our opinion weld-clad ends offer clear advantages over the other production variants: the production process can be controlled, it is cheaper and reproducible. With this in mind, we at BUTTING prefer weld-clad upset ends.”
The stainless steel landscape is changing fast, whether in terms of production, fabrication or consumption. Production has shifted to Asia at a pace which has left many gasping, especially in Europe, which has had to take drastic steps to adjust. Additive manufacturing is transforming not only whole industries such as aerospace and orthopaedics, but driving the creation of new alloys. Meanwhile, automized welding is streamlining fabrication. Finally, new applications and new industries are blazing a trail in the pattern of consumption, whether in infrastructure, vehicles, ships or biofuels.

By James Chater

Production
Who would have thought it? In 2006 China produced just 13% of the world’s stainless, whereas Europe produced 34% and the Americas 39%. By 2016, China’s share of production had quadrupled to 54% whereas the EU’s had halved to 18% and the Americas’ to 6% (ISSF figures).

The mind-boggling surge in Chinese production has transformed the stainless steel landscape. European producers have had to rethink their business model and make judicious though often painful decisions about how and where to invest. The Americas’ share of production has likewise been affected.

In the last two years, however, there have been signs that things are improving in line with global economic growth. Stainless steel meltshop production was up 5% in the first half of 2017, setting a global record. The highest increase was registered for the USA (24%), compared to 4.2% for China, 5.2% for the rest of Asia, and 2.3% for Europe.

China is the world’s largest producer and the country with most of the world’s largest producers, but its production increase is slowing. Its 4.2% increase is lower than that of previous years, whereas other Asian countries are
catching up. The world’s largest stainless producer is now Tsingshan Holding Group, which recently shifted some of its slab production to a newly commissioned plant in Indonesia. The company has recently formed joint ventures with Schmolz + Bickenbach and Allegheny Technology (ATI), thus positioning itself as a vertically integrated company ranging from mining interests in Indonesia right through to state-of-the-art processing facilities. At the same time, Tsingshan’s actions are part of an overall cut in Chinese capacity after years of over-production that have distorted global markets and placed a strain on China’s environment. Several Chinese stainless steel mills have cut production, while others have been ordered to close. And China’s stainless products still face anti-dumping tariffs in the USA and Europe. In the rest of Asia, South Korea’s Posco posted strong Q3 results, while India has emerged as an important producer, having overtaken Japan to occupy second place in 2016. Its potential for further growth, especially in its domestic market, is immense, and there has been a marked shift away from kitchenware to the engineering and construction sectors. In Europe, market share continues to decline. However, after several bouts of reorganization, mill closures and job losses, the situation seems to be stabilizing (1). Sandvik has made a spectacular turnaround, with improved profits and prospects for strong growth. The strongest success was scored by Spain’s Acerinox, which tripled its year-on-year profits in the third quarter. Its US mill in Kentucky was opened on 29 October 2017. The USA’s remarkable increase is hard to explain. Part of it reflects continuing economic recovery and an increase in steel production generally (up 2.5% year on year as of 22 July 2017). Another factor is no doubt the vigorously healthy state of the nation’s aerospace industries, which has increased demand for forged parts from companies such as ATI.
**Stainless types and grades**

The market share of the different families of grades (200s, 300s, 400s etc.) is stable, showing no significant developments. The nickel price sagged in the middle of the year but has put on a spurt since May and is now at 5.15 USD/lb (as of 28 November), about where it was in December 2016.

The share of duplex grades is hard to quantify, but still seem to make up no more than 1% to 2% of world market share. One may detect a trend towards greater use of duplex, especially the lean grades, in infrastructure, and especially bridges in coastal regions, where better corrosion resistance is needed alongside the usual load-bearing requirements (2).

The year 2017 produced at least two exciting breakthroughs for steel alloys. Researchers at the University of San Diego have developed an alloy, SAM2XS-630, that withstand an impact without deforming permanently. Candidate applications include drill bits, body armour, and meteor-resistant casings for satellites. The second invention is an alloy that bend like gum. Researchers at the Max-Planck-Institut für Eisenforschung developed a titanium alloy (with niobium, tantalum and zirconium) that, when deformed, bends instead of breaking; in other words, it is extremely ductile. This alloy can be used for the protective casing round an aircraft turbine, to protect it from hail or a bird strike.

**Fabrication**

3D printing (additive manufacturing) is the engine driving much of the growth and transformation in all manufacturing industries, including those involving stainless steel and nickel or titanium alloys. The aerospace industry is the most obvious beneficiary, though orthopaedics is now the fastest growth area affected by 3D printing.

The two countries that are leading the 3D revolution are the USA and Germany; China is not far behind. In the USA, GE made a significant investment, acquiring Concept Laser, a leading pioneer in metal powder bed fusion, which can 3D print with titanium, nickel alloys, precious metal alloys, steels, aluminum and cobalt-chromium. Meanwhile, researchers at the Lawrence Livermore Laboratory are pioneering ways to strengthen 3D-printed stainless steel parts by reducing their porosity. In Germany, the Technical University of Munich will partner with Oerlikon to set up a new institute for additive manufacturing in Garching. In October the German Research Foundation set up a programme to develop powder materials better suited to laser-based 3D printing. China is investing 300 million USD in 3D technology over three years.

The same period saw closer integration of 3D with more traditional technologies, including the use of “hybrid” machines that can switch between additive and subtractive manufacturing techniques within the same production line. Robotics, supported by ever more sophisticated software, are fast transforming the welding and cutting industries (3).

3D technology is affecting not only fabrication but also the materials themselves. Thus a technology developed by XJet is affecting the grain structure of metals, making it possible to print multi-material metals. Increasingly, companies are asking 3D manufacturers to come up with application-specific materials, and alloys are being developed or tweaked specifically for 3D applications, for example EOS’s StainlessSteel 17-4PH IndustryLine metal powder, a strong, corrosion- and acid-resistant material.
designed for manufacturing surgical and orthopaedic instruments. The rise of 3D manufacturing has impacted several industries. First, 3D is being used not just to manufacture things, but also the things that make things: tooling, factory machinery and so on. Secondly, industries such as orthopaedics and aerospace are being transformed by the opportunity to make better products at a lower cost and in a more sustainable way.

**Industry sectors**

**Medical**
As outlined above, orthopaedics is one of the fastest-growing industries associated not only with 3D manufacturing but also with the consumption of titanium, tantalum and other precious alloys. The fastest growing are knee reconstruction systems, spinal fusion devices and non-load-bearing extremity fracture devices. The industry is changing fast and new precedents being set all the time. Recently an 84-year-old Chinese man has become the first patient in the world to receive a 3D-printed tantalum knee-joint.

**Aerospace**
The opportunities in aerospace are scarcely less exciting. Airliner deliveries are at an all-time high and are expected to increase by about 7% in 2017 and just over 10% in 2018. New orders have slowed down, but an eight-year backlog ensures handsome profits for the foreseeable future. In addition, the tense international scene suggests military spending will rise, and the USA has already announced increased spending for 2018. Old aircraft are being phased out for new ones that use more weight-reducing titanium and CFCs in their construction, along with faster burning engines that rely on titanium for their performance. These new planes are being supplied by Airbus, Boeing and Comac, while GE, which uses 3D printing to build its jet engines, has teamed up with 3DP specialist Arconic to advance the technology even further.

**Auto**
Just as aircraft designers use titanium to create lighter structures, so too the auto industry is using more stainless steel to reduce the weight of vehicles. Stainless is an attractive material because of its weight-to-strength ratio and because of its superior shock.
absorption. Nickel is used in the batteries of electric vehicles, so its use will rise as electric motors replace internal combustion engines. Stainless steel (Outokumpu’s Forta H1000) is used in the protective housing of the batteries of hybrid cars. It is also used in car doors, bus bodies, exhaust systems, motor shafts, silencer wool and trailers. Not only cars, but also ships, freight vehicles and buses are making more use of stainless, especially duplex grades, with their favourable strength-to-weight ratios (4).

Energy and process industries

Upstream oil and gas has been in the doldrums as projects were cancelled and lay-offs occurred because of a perceived oil glut. Now, with tensions in the Middle East rising, prices have started to move up again, which is bullish for projects located outside the Middle East: the North Sea, the Gulf of Mexico, Africa, US shales, Australian LNG. One of the fastest-growing energy industries is LNG, with US shales gas, improved transport and more efficient shipping combining to create a global market. The applications for LNG are expanding away from the traditional gas-fired power plants to include transport and the exploitation of stranded gas.

Traditional energy industries are interacting with younger techniques, for example wind power is being harnessed to actuate water injection, and shale gas is being extracted in offshore locations. Low oil and gas prices acted as a boost to the refining and petrochemical industries. Most of the expansion in refining is coming from the Middle East and SE Asia, with a clear shift from mature to emerging markets. SE Asia also dominates in the chemical and petrochemical sectors, which are also enjoying healthy growth. Despite slowing growth, China’s dominant position remains unchallenged, though the rest of Asia is bristling with projects. Remarkable breakthroughs in the chemical industry include bio-based chemicals, energy reduction (for instance the generation of ammonia at room temperature or more energy-efficient ways to produce hydrogen) and advances in catalysis technology, in which nickel is a likely candidate to replace palladium and platinum.

Another growing field is bio-fuels, where capacity is forecast to increase from 66.1 billion gallons a year in 2014 to 61 billion in 2018. The more novel feedstocks are growing faster than more traditional ethanol and biodiesel. Waste oil-to-biodiesel, waste-to-energy, cellulosic ethanol and renewable diesel are the fastest-growing sectors. Power generation from fossil fuels is characterized by a shift away from coal- and oil-fired plants towards gas, nuclear and renewables. Renewable power is especially promising as an expanding market for stainless and alloys. Hydroelectricity still accounts for the lion’s share of the renewable energy mix and is still expanding. However, its viability is in doubt because of erratic weather patterns due to global warming. Wind and solar energy show more promise and, like hydroelectricity, consume steady amounts of stainless steel. The years 2016-17 saw a historic shift in renewables, when energy storage entered the mainstream. Storage technologies can be thermal, in batteries, HTS magnets, hydrogen-based or cryogenic (using liquefied air); all these processes offer opportunities for stainless steel. Closely bound with solar energy is desalination, a technology which will be in high demand in a thirsty world, and which consumes large amounts of duplex stainless steel.

Water management in general is a growth industry as the world’s megacities expand even further or new ones are built. Architecture and infrastructure are also growth sectors, with the Middle East and SE Asia leading the way in ambitious megaprojects: buildings, roads, bridges, railways, tunnels, disaster mitigation, street furniture... If even half the projects announced for Kuwait, Saudi Arabia, UAE, India and China ever get built, the opportunities for stainless steel producers will be huge.

References

(1) See my survey on the EU in this issue.
(2) See my “Duplex” survey in this journal, November 2017.
(3) See my “Welding” survey in this journal, December 2017.
(4) See my “Duplex” survey.

Bombardier’s EMU (electric multiple unit) trains use stainless steel in their construction. They have been sold to India and China.

Duplex and super-duplex are standard in the umbilicals used in offshore oil and gas fields. Depicted here, umbilicals made at the Vallourec Umbilicals plant in Venarey-les-Laumes, France. Photo: Stephan Caso.
Hybrid Steel opens up new design possibilities

Jan-Erik Andersson, Ovako’s Senior Group Technical Specialist, explains how the high-tech steel producer’s innovative Hybrid Steel® family is opening up new possibilities to achieve exceptional performance in highly stressed components while also offering the potential for enhanced corrosion resistance.

Our aim in creating Ovako’s new Hybrid Steel® was to make the high-performance properties of expensive, batch-produced steels available in a new cost-effective family of steels suitable for large scale production. This required us to challenge the long-established divisions between the specialized steel categories of tool steel, managing steel and stainless steel and merge their specific properties with the production economy of conventional engineering steel. The result is the Hybrid Steel concept developed to offer superior mechanical and fatigue strength to conventional steels, especially at high temperatures. With over double the yield and tensile strength of conventional steel when used at temperatures up to 500°C, it has particular appeal for use in engine components, bearings and tools which operate in demanding conditions. The chromium and aluminum content in Hybrid Steel also improves its corrosion and oxidation resistance significantly.

Bypassing the reliance on remelting processes

In developing Hybrid Steel, we have drawn on cutting edge research to help our customers meet the challenge of designing durable, highly stressed components. Today, the production of most engineering steels used at elevated temperatures relies on expensive remelting practices. This results in a highly alloyed secondary hardening steel that is strengthened by the precipitation of fine alloy carbides during the tempering process. But these steels are prone to ‘segregation’, in which some of the alloying elements migrate to areas where they cause weakness. The need for careful control of segregation makes these steelmaking processes more complicated and often more expensive compared to high volume steel making. Our aim was therefore to develop steel with low segregation propensity but with good strength, while also being suitable for mass production in traditional electric arc furnaces.

This solution needed to bypass the reliance on expensive remelting processes and to mostly use readily available, inexpensive alloy elements. It became clear that the key to success was to adopt a hybrid approach in which the steel would utilise two different, but complementary hardening mechanisms. The unique properties of Hybrid Steel are made possible by this combination of two well established strengthening mechanisms. The first, secondary carbide hardening, comes from the formation of small carbide particles which make the steel more resistant to deformation, and is usually associated with tool steel production. The second, known as precipitation hardening, involves different intermetallic precipitation phases which increase the steel’s strength, and is normally used for managing steel production. Hybrid Steel represents the most successful attempt to date to bring these two mechanisms together.

The resulting makeup of Hybrid Steel is low in carbon and contains a number of carefully controlled alloying elements - most importantly chromium, molybdenum, vanadium, nickel and aluminium. The relatively reduced need for expensive alloying elements compared to existing specialised steel helps keep the production cost of Hybrid Steel down.

The presence of these alloying elements enables Hybrid Steel to develop its full properties after tempering at an elevated temperature of 500-600°C. While the first two members of the Hybrid Steel family have a chromium content of around 5%, it is foreseen that future additions will include variants with higher levels, thus bringing Hybrid Steel firmly into the range of stainless steels.

Detailed work with component manufacturers

Hybrid Steel made its public debut at Euromat in September 2017. However, before that point, detailed work had been ongoing with component manufacturers for more than a year. While the individual hardening concepts exemplified in Hybrid Steel have been understood for a long time, technical barriers meant that combining them in a single product was particularly challenging. This is because it takes a high level of metallurgical expertise to execute successfully. Ovako has a particular advantage in this area since our business is founded on the manufacture of steel within very closely controlled parameters, such as our BQ-Steel/IQ-Steel brands of clean steel.

The experience gained from the application of the highly stringent
processing processes required for the production of clean steel has proven particularly instrumental in the development of Hybrid Steel. And a crucial factor in the new steel’s versatility is that the combined level of oxygen, sulphur and nitrogen is closely controlled.

More options at lower costs
Due to the high cost and segregating tendencies of existing steel options, conventional engineering steel is often a limiting factor in elevated temperature applications that require high levels of mechanical and fatigue strength and oxidation resistance. However, the new alloying philosophy exhibited in Hybrid Steel and its resulting properties offer increased design options at lower costs. One major way Hybrid Steel does this is by reducing the number of manufacturing steps required to produce a finished component. Because the steel develops its hardness after tempering, production engineers can machine a component while it is still in a softer condition, and then harden it without any risk of distortion. This is a direct result of the intermetallic precipitation processing stage of the production of Hybrid Steel, where the strength of the steel is increased during tempering. A reduction in manufacturing stages leads to a reduction in manufacturing cost and complexity. For example, the traditional route to manufacturing a tool component might involve forging, soft annealing, rough machining, a succession of quench and temper processes, followed by hard machining. In contrast, a component made of Hybrid Steel can be immediately hardened after forging, before being tempered and ready for application.

Furthermore, while welding processes often result in a loss of steel properties, Hybrid Steel opens up the capability to create welded components in which a post-welding heat treatment will result in the desired high strength and weld homogeneity. In addition, Hybrid Steel is particularly suitable for nitriding, which can take place at the same temperature as its tempering temperature. The result is a thin nitried surface layer that provides the strong, hard-wearing properties required for critical components such as those used in power transmission systems, without sacrificing a high core hardness. This core hardness also means that Hybrid Steel is ideal for plasma nitriding, making it a suitable option for specialised tool steel applications.

Corrosion resistance
The chemical composition of hybrid steel, especially the chromium and aluminium content provides enhanced corrosion resistance. Preliminary testing, as shown in Figure 3, indicates a performance already approaching that of lower end stainless steels - at only 5% chromium content.

A wide variety of potential applications
The many advantages of Hybrid Steel means that it will have a wide variety of potential uses in highly demanding applications such as engine components, bearings, fuel injection components, mining tools and machining tools. A comprehensive exploration of its diverse uses is only just underway and these are sure to increase, particularly as we start to investigate the new possibilities offered by Hybrid Steel’s corrosion resistance. Göran Nyström, Ovako’s Executive Vice President responsible for Marketing and Technology and previously VP of Sandvik Materials Technology with many years in the stainless steel business, poses this question: “What new opportunities could such an ultra-high strength and weldable steel bring to the world of stainless steels?”

The Hybrid Steel story is only in its opening chapter. Rather than being one type of steel, Hybrid Steel should be regarded as a new concept representing a family of steels from which different grades will emerge over time to suit specific customer needs. At Ovako, we believe that Hybrid Steel could prove to be one of the most significant developments in the steel industry for decades.

To learn more about Hybrid Steel visit: www.ovako.com/Products/Hybrid-Steel/

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**Figure 2.** Hybrid Steel contains carefully controlled alloying elements

**Figure 3.** Preliminary ranking of hybrid steel for corrosion resistance. ISO 15158(mod) 10mV/min 0.01M NaCl.

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**Table:**

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<td>6</td>
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**About the author**

Jan-Erik Andersson is Senior Group Technical Specialist at Ovako. He was educated at the Royal Institute of Technology (KTH, Stockholm) and worked at the Swedish Institute for Metals Research carrying out advanced research related to steel inclusions, fatigue and heat treatment before joining Ovako’s research department. Ovako is a European producer of long special steel products for the heavy vehicle, automotive and engineering industries in the form of bars, tubes, rings and pre-components. The company has production at 9 sites and sales companies globally.
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CHAIRMAN’S CALL

It is a great pleasure to invite all those who enjoy the benefits of duplex stainless steel to participate in Duplex World 2018 in Düsseldorf, Germany. In my career in the chemical industry I have seen the use of duplex stainless steels expand greatly. The availability of many grades in many product forms has made this material a “go-to” material in many chemical processes. Duplex stainless steels are quite often the economic choice for lowest long term cost of ownership due to their high strength and corrosion resistance to both process conditions and plant environments. But duplex stainless steels have many uses outside my own industry. In petroleum production and refining duplex can provide resistance to hazardous environments thus allowing safe operations to be maintained. In the pharmaceutical, food, transport and architecture sectors the corrosion resistance and low temperature toughness of duplex result in a long service life and low maintenance. How can you hope to benefit at Duplex World 2018? There will be no better opportunity to interact and network with researchers, corrosion experts, fabrication experts, designers, producers and stockists. Technical sessions will afford numerous opportunities to learn about the latest developments and how we might push the current boundaries in applications of duplex. Exhibitors will show case a wide variety of duplex-related products.

It is my very great honor to chair Duplex World 2018. On behalf of the Steering Committee I invite you to join us in Düsseldorf. Please consider submitting an abstract for presentation at the conference. Submissions are welcome on any topic related to duplex. Please help us to create an exciting conference program.

David Barber, Global Improvement Leader - Materials Discipline, The Dow Chemical Company
Chairman of the Duplex World Seminar & Summit

EXHIBIT AT DUPLEX WORLD 2018 – BOOK ONLINE AT www.duplexworld.com/duplex2018
3 WAYS TO PARTICIPATE

The Duplex World Steering Committee invites duplex experts from all industries to take part in the dynamic and interactive technical sessions. Come and join the discussions, showcase your expertise, and explore the endless possibilities for business networking!

Explore technical issues in-depth during discussion-based seminars

1 DISCUSSION-BASED SEMINARS

Join a panel of duplex professionals in one of our discussion-based, interactive seminars. Discussions and the exchange of ideas and experience are a core part of the Duplex World experience. The Seminars focus on a specific topic, e.g. the IOGP JIP on standardization of equipment and packages; welding issues; application limits for duplexes at elevated temperatures, etc. The interactive seminars explore a theme with open discussions supported by panelists who give short presentations. Panelists are not required to prepare a full paper but must they must submit a 300-500 word abstract outlining the material they would like to present by 20 February 2018.

2 TECHNICAL PAPER SESSIONS

Duplex experts may present a technical paper during one of the technical paper sessions. Speakers will be allocated 15 minutes plus 5 minutes question time for their presentation. Moderators will ensure speakers keep to their allocated time and direct questions to the speakers. If you would like to present a paper you must submit your 300-500 word abstract outlining the topic and content of your material for consideration by the Steering Committee by 20 February 2018.

3 NEW! INTERACTIVE FORUM

End users and EPCs are invited to join the unique Interactive Forum addressing the most pressing issues facing producers, users and specifiers of duplex stainless steels. This open conversation will explore a range of topics during a dynamic panel discussion, addressing both pre-determined topics and questions from the audience. End users and EPCs interested in joining the Interactive Forum please email Mrs Joanne McIntyre at j.mcintyre@kci-world.com for information.

Join the conversation during dynamic technical sessions

**Participation is free of charge for end users and EPCs.

SUBMIT YOUR ABSTRACT

YOUR 300-500 WORD ABSTRACT/OUTLINE OF YOUR PRESENTATION OR PAPER MUST BE SUBMITTED BY 20 FEBRUARY 2018 FOR EVALUATION BY THE STEERING COMMITTEE TO MRS JOANNE McINTYRE, SEMINAR COORDINATOR EMAIL: J.McINTYRE@KCI-WORLD.COM TEL: +31-575-585-298

DATES TO REMEMBER

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<td>Abstract submission deadline</td>
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<tr>
<td>Notification of acceptance</td>
<td>1 April 2018</td>
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<tr>
<td>Deadline for final papers/Power Points</td>
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Possible Presentation Topics

The Duplex World Seminar aims to cover a wide variety of applications for the specification, manufacture and use of duplex stainless steels. Some possible topics for presentations include, but are not limited to, the following:

- Case study applications
- Casting & forging
- Chemical & Petrochemical
- Cladding and overlay
- Construction & architecture
- Desalination
- End user requirements
- Heat exchanger fabrication
- Heat treatments
- High & low temperature applications
- Improving quality and avoiding failures
- Innovations & new grades
- IOGP Joint Industry Project on standardization of equipment and packages
- Lean, super & hyper duplexes
- Oil & gas applications (offshore & onshore)
- Welding

The final selection of the papers/presentation for the Seminar will be made by the Duplex World 2018 Steering Committee. They will be selected on the basis of:

- Content quality
- Innovation and topicality
- Focus on application experience and practicalities, where possible presenting case studies
- The presentation of practical challenges (and/or solutions)
- Technicality: commercial presentations will not be accepted

Send your abstract by 20 February 2018 to: Joanne McIntyre | Conference Coordinator
Email: j.mcintyre@kci-world.com | Tel: +31-575-585-298

Why Join the Duplex World Seminar?

Knowledge exchange

*Duplex World has an outstanding reputation for promoting and aiding knowledge exchange. Presentations have an application orientated approach – problems & solutions, research results, new developments & applications, case studies, market trends.*

Showcase your expertise

*This is a premier networking event where every attendee is involved with duplex. Presenters are recognized as leading experts on the specification, production and use of duplex stainless steel."

Business network

*This is a highly targeted event. The network you will build during the event will be of benefit once you return to work and for the rest of your career.*
Showcase your company!

The Van Der Valk Airport Hotel in Düsseldorf is a spacious location where workshops, exhibition stands, networking lounges and table-top exhibitors will all be located on the same floor, ideal for facilitating the flow of visitors and delegates. It’s the ideal opportunity to showcase your company, products, services and personality, and network with clients in a relaxed yet professional atmosphere.

Companies have the choice of maximizing their presence with traditional Exhibition Stands, Table Tops or Networking Lounges. All are provided as complete packages – including staff refreshments and lunch each day and access to the Seminar for two members of staff – in order to ensure that your participating is achieved with ease. Why not maximize your presence and book both an Exhibition Stand and a Networking Lounge?

**Exhibition Stands** provide an ideal platform to showcase your company products and activities. Stand packages include stand building, basic furniture, free wifi, two days catering and Seminar tickets for two members of staff.

**Networking Lounges** provide an opportunity for companies to network directly with clients and peers in an informal setting ideal for private discussions. Lounges include couch, chairs, table, back-drop with company logo, free wifi, two days catering and Seminar tickets for two members of staff.

**Table Tops** provide an ideal platform for smaller exhibitors to showcase their company products and activities. The Table Top package includes a high table and two barstools, roll-up with company logo, free wifi, two days catering and Seminar tickets for two members of staff.

Special sizes of Exhibitions Stands and Networking Lounges can be provided on request. Additional staff may be registered for a small fee (details to be provided).

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### Table Top

2,900 Euro

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Metal powders: a niche to watch!

Despite product developments and vast investments around the world, the metal powder industry has not yet really taken off, nor have the sceptics been satisfied. Acknowledging that this is a technology for which home-grown expertise is essential for competitiveness, many countries are developing a powder metallurgy industry. As a result developments can be seen almost on a daily basis in every region of the world. Yet, perhaps because of this rapid development and the vast choices available, players in the market seem to be ‘frozen’ and are not really bringing these developments to the market yet.

By Benedikt BLITZ, Managing Director SMR Premium - High Value Metals Market Research, Germany

The most hype in recent years is clearly attributed to additive manufacturing (AM or also 3D printing), although there are other compaction technologies such as press & sinter (P&S), metal injection moulding (MIM), hot/cold isostatic pressing (HIP/CIP) as well as coating technologies that offer interesting growth opportunities. In particular, cooperation and interaction between the supply (e.g. powder production, machine maker, etc.) and the demand side (e.g. enduser, OEM’s, machine operator, etc.) needs to be improved. The success of such cooperation can be seen in associations in other industry sectors, for example the Italian Stainless Steel Development Association - Centro Inox or the Australian Stainless Steel Development Association - ASSDA.

Market volumes
In terms of market volumes the powder market is significant in terms of tonnage, however most is consumed by P&S using mainly standard or commodity powder. Roughly 5% of the total powder market can be seen as a specialty powder market, demanding more advanced powders that are used for special P&S, Coating, HIP, MIM and AM.

In recent years AM has grown rapidly compared to other compaction technologies, although they are also showing steady growth, acceptance and development in the market place. Compound annual growth rate (CAGR) from 2016 to 2022 are for coating 5.5%, HIP 6%, MIM 11.6%, AM >30%. Although there exists a certain overcapacity for the supply of special powders, it very much depends on the market development and acceptance by different industries to turn this surplus into a deficit within a few years. Depending on the market development scenarios this deficit could appear as early as 2020, of course also depending on different scenarios on the supply side.

Additive Manufacturing - AM
AM has moved from prototyping to production. The technology is ready and available. On a daily basis key players from different industries are demonstrating what is possible with AM today. However the market needs more production examples (e.g. metal AM parts in use in engines, turbines, medical devices or cars) to really take off. AM started with prototyping, then moved to tooling and part replacement, then part consolidation and is now finally playing its full strength in DIAM parts (parts that are designed for AM). The opportunities offered by AM to re-engineer parts or functions should also prompt an
increase in volume, but requires the willingness of final customers to re-engineer their parts and not simply copy what is done with conventional technologies. Some recent highlights should be mentioned. GE Additive is the front runner, not only using AM parts but also introducing new printer models (with building envelopes of 1m³ and multiple operating lasers, etc.) that are helping to speed up market development. Several partnerships to drive this development were announced recently. Also record sales of AM machines confirm the interest from the market, although many of these machines are installed at R&D centers, universities, etc. Another area where AM is on its way is the spare part business. Instead of storing tonnes of spare parts and shipping them around the world, they can be printed when needed, in the right specification or even as an improved version. Low industry standardisation, limited availability of data for simulation software and models, as well as safety related issues present critical areas that the industry needs to work on.

**Metal Injection Moulding – MIM**

MIM has proved to be a competitive manufacturing process for smaller precision components that in fact would be more cost intensive if produced by conventional or other production processes as they would require extensive finish machining or assembly operations. MIM is used because of its capability to produce large as well as smaller volumes of complex shapes and special products. The limitation of MIM is the overall part size, with most parts generally not exceeding 250 g today although some players are capable of making parts weighing a few kilograms. The development of two-component MIM parts and micro MIM parts are promising for future applications. The main material used today is stainless steel followed by super alloys. Therefore a high demand of fine powders is present. Beside traditional markets like firearms and medical (mostly USA), automotive and industrial (Europe) as well as electronics (Asia), MIM is now considered by the aerospace industry when specifying parts for the next generation of aircraft engines, starting with the replacement of non-critical parts.

**Hot Isostatic Pressing - HIP**

Most installed HIP units are used today for the densification of castings and MIM parts, as well as post treatment for AM parts. The most important use of PM and HIP processes are the production of high speed steel and tool steels. Here the powder is fed in a metallic container (capsule/canister) having the shape of a billet which is then transformed into bars, blocks or wire rod through the conventional forging, rolling and drawing process. HIP has also become interesting to make NNS (near net shape) and NS (net shape) parts. These products can be found in the oil & gas, energy process and aerospace industries. The advantages of HIP can clearly be seen when producing parts of much larger sizes (above 5 tons) than it is.

"**Investments over the entire PM industry will lead to a price decline in raw materials & end products by 40-60% in the next 10 years**"
possible with other PM processes, with a virtually unlimited capability for complex shapes and geometric features. HIP is applicable to difficult-to-compact and expensive materials such as super-alloys, titanium, tool steels, stainless steel, etc. For HIPing most of the installed capacity can be found via service providers like Bodycote but in recent years more companies have invested in their own HIP capacity.

Other interesting approaches are Alcoa’s Ampliforge process or Metalvalue’s MMS Scanpac process, the latter to make a bridge between small and medium sized parts. Also the implication of cold spray technology like company Titomic, applying the Titomic Kintetic Fusion (TKF) process for making titanium parts much faster and at much lower costs, is gaining attention from several end users in the market.

**Powder production**

The processes mentioned require mainly special powders with key properties such as particle size, particle shape, flow ability, right particle size distribution PSD (that is depending on application), to only name a few.

Most of these special powders are produced via gas atomisation, which is the process of choice for larger volumes of high quality powders. However, depending on the powder grade and particle size, other production technologies are in use or have been developed. An interesting technology is plasma spheriodisation from Tekna Canada, in which almost any kind of powder input form (crushed HDH, sponge, reduced, water atomised, etc.) can be turned into high quality powder; furthermore used powder or off-spec powder can be recycled and reconditioned to be used again.

To follow the recent hype in the different technologies a number of players are currently investing in powder production capacity. A number of newcomers are also expected to appear.

**Conclusion**

Powder metallurgy and its technologies are here to stay. Major players (powder makers, machine makers, and end users) will focus more on acquiring increased production levels with new applications to gain market dominance. However in order to avoid turning all this hype into a big ‘powder bubble’ it will be of utmost importance for each player to have up-to-date market insights in order to make their business model a successful one.

Data handling will become a very important factor as will be the topic of intellectual property, especially in AM. Theoretically every person who has access to the data can manufacture the product in this industry. Thus data storage, data delivery and data security to block unauthorized access will become key issues.

Major investments over the entire PM industry will lead to a price decline in raw materials and end products by up to 40-60% in the next 10 years. EBIT margin allocation among powder makers, equipment makers, and end users as well as analysis of who has been enjoying the highest margin so far, and whether they will continue to do so in future, should be considered.

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**About the author**

Benedikt Blitz is Managing Partner of SMR Premium and holds a degree in Process Technology and Environmental Technology. SMR Premium is an associated company of Austrian based SMR – Steel & Metals Market Research GmbH, with a focus on providing market volumes, market structures and competitor analysis as well as market forecasts in the world of high value metals & markets. It has a focus on remelted steels, forged products and high value metals (powder metallurgy, Ti, etc.). For more details see www.smr-premium.com.
Communications: a ‘must-have’ tool for a materials engineer

SSW first had the pleasure of meeting Material and Inspection Specialist Mrs. Sari Musch in September 2015 when visiting the Neste refinery at Porvoo, Finland. There, in the company’s central office, she kindly outlined some of her work related to stainless steels. Two years later, SSW found it high time for a return trip to Finland to catch up with Mrs. Musch and her many and varied projects.

By David Sear

According to Mrs. Musch herself she does not really receive that many outside guests at the Porvoo refinery. And that’s something of a surprise for whenever SSW visits we are always treated to a friendly welcome, a hot cup of coffee and the opportunity to listen to an honest, in-depth review of materials. And make no mistake about it, Mrs. Musch can talk with authority about materials from various angles: properties, selection, failure analysis, welding, etc. For she has continually looked for opportunities to expand and improve her knowledge of as wide a range of materials as possible. This is exactly why she joined the Neste refinery back in 2012, eager to work with stainless steels and some of the more exotic CRAs. She has certainly had her wish, having been involved in plenty of interesting cases within the refinery gates. For example, she has focused attention on the refinery’s water quality which was affected following a leakage of resin balls from the ion exchange system. Now when safely contained inside the ion exchange unit those balls do an excellent job in removing calcium and magnesium from the boiler feed water. However, when allowed to escape from the ion exchanger, to circulate and to subsequently become exposed to higher temperatures, these self-same balls can degrade, causing corrosion problems elsewhere.

As Mrs. Musch explains, that’s because the resin balls are fully saturated with positively charged sodium ions (Na+) and contain a lot of sulphur in the form of sulphonic acid. The resin starts to decompose at elevated temperatures where evaporation takes place. The decomposition process is fairly complex but results in the formation of both sulphuric acid and sodium hydroxide. Comments Mrs. Musch: “So what we have is both an acid and a base. In some instances these two compounds will neutralise each other. Indeed, pH readings in some areas may show that the water is perfectly all right. However, these readings can create a false sense of security as, for example, sodium hydroxide can accumulate under surface fouling which leads to severe pitting corrosion or stress corrosion cracking.” The ideal solution from the scientific perspective, she indicates, would be to shut down the refinery, drain the feed water and condensate tanks and clean out the balls. However, there are clearly good economic reasons for waiting until the next scheduled outage, as closing even parts of a refinery can lead to an immediate loss of revenue. “We therefore have to accept that the resin balls will continue to be a concern for items such as heat exchangers, boilers, etc. For example, the tube bundles need replacing more frequently than normal. Fortunately now that we are aware of this particular corrosion mode we can take all the necessary steps well in advance. However, we are currently looking to hire a manager to be responsible for the water and steam systems so I am confident that he or she will be able to push ahead with the actual implementation of the clean-up project. This is an indication that the
top management is seeing the need for a strong ownership for the boiler and the water quality issues.”

Sulphur level

At this juncture SSW decide to ask Mrs. Musch for an update on some of the other topics she raised two years previously. Such as, for example, her concern that rising sulphur levels in the crude oil feedstock might necessitate using chromium alloys as an alternative to carbon steels in certain areas.

In reply, Mrs. Musch notes that colleagues from local engineering company Neste Jacobs had in fact just concluded a material upgrade project in the crude oil distillation systems. “They reviewed the suitability of existing piping and equipment for increasing sulphur levels. This evaluation highlighted the need to upgrade from carbon steel to 8Cr or even to 9Cr/12Cr steels. However, if sulphur levels continue to rise than perhaps a further step up to stainless steels will be the next choice.”

“Since joining the Porvoo refinery I have had plenty of hands-on experience with stainless steels, duplexes, Inconel, etc”

Another research project instigated by Mrs. Musch in 2015 was to address fouling in a tank fabricated from 321 stainless steel clad onto a carbon steel base layer. To that end she had coupons installed inside the tanks. With the coupons now having been removed and examined, Mrs. Musch says she needs to free up time to properly analyse the results. “Fouling can accelerate corrosion, so is something that I take very seriously,” she notes.

Duplex cracks

A more recent area of attention for Mrs. Musch is a hydrogen-rich process unit, where cracks have been found in a duplex vessel. Commenting, she says: “the investigation is still ongoing but there is some evidence to suggest that improper manufacturing or welding practices may be part of the problem. The preliminary results revealed some microstructural anomalies which could have made the material susceptible to cracking.” “It is important for everyone involved to remember that duplex is absolutely not the same as carbon steel,” she continues. “For example there are clearly defined welding procedures which must be followed. This type of information should therefore really be included in the purchase orders so that everyone involved is properly informed in advance. Only certified welders should be used but even then the procedures should be discussed so that they really appreciate what is needed and why. The cooling speed for one is a key parameter. But it is equally important for managers to consider what it is like for a welder to work inside a vessel installed in the field. In other words: make sure the welder has easy access to the work area and does not have to strain to reach the weld.”

Straightforward language

Mrs. Musch goes on to say that the ability to distil complex engineering issues into easily understandable language is an important skill for materials engineers. “We have developed a rich vocabulary that enables us to precisely define materials phenomena. That is ideal when looking to explain complex ideas to our immediate peers. But we also need to be able to discuss materials issues with specialists in other fields. For example, that could be with a refinery owner about the need to change materials. Or with a welder, to explain why it is important to follow specific procedures for welding exotic materials.”

This is why Mrs. Musch avoids using technical jargon during her regular presentations to Porvoo staff. “Start discussing microstructures and you can see people quickly becoming disengaged. Therefore I try to use a straightforward language to ensure that everyone understands and can contribute to discussions. My presentation shows materials failures that can happen in a refinery and how they can be avoided. For example, I recently explained to process operators why they need to be really careful with the operating window. If for whatever reason they raise the process temperature so that the material temperature is raised by just ten degrees that can reduce the furnace tube life by fifty per cent! That is a simple message but one which everyone can immediately understand.”

Material and Inspection Specialist Sari Musch in the central office of the Porvoo refinery in Finland

www.stainless-steel-world.net

The Porvoo refinery is located within an hour’s drive from the capital, Helsinki

Stainless Steel World January/February 2018 39
Breakthrough in 3D printing 316L

Ground-breaking research into the 3D printing of 316L stainless steel has provided valuable insights into how to control the mechanical properties of 3D printed materials.

Text from the Lawrence Livermore National Laboratory, Photos by Kate Hunts/LLNL

“Marine grade” stainless steel is valued for its performance under corrosive environments and for its high ductility -- the ability to bend without breaking under stress -- making it a preferred choice for oil pipelines, welding, kitchen utensils, chemical equipment, medical implants, engine parts and nuclear waste storage. However, conventional techniques for strengthening this class of stainless steels typically comes at the expense of ductility.

Lawrence Livermore National Laboratory (LLNL) researchers, along with collaborators at Ames National Laboratory, Georgia Tech University and Oregon State University, have achieved a breakthrough in 3D printing one of the most common forms of marine grade stainless steel - 316L - that promises an unparalleled combination of high-strength and high-ductility properties for the ubiquitous alloy. The research appeared online in the journal Nature Materials.

“In order to make all the components you’re trying to print useful, you need to have this material property at least the same as those made by traditional metallurgy,” said LLNL materials scientist and lead author Morris Wang. “We were able to 3D print real components in the lab with 316L stainless steel, and the material’s performance was actually better than those made with the traditional approach. That’s really a big jump. It makes additive manufacturing very attractive and fills a major gap.”

Wang said the methodology could open the floodgates to widespread 3D printing of such stainless steel components, particularly in the aerospace, automotive and oil and gas industries, where strong and tough materials are needed to tolerate extreme force in harsh environments.

Overcoming porosity

To successfully meet, and exceed, the necessary performance requirements for 316L stainless steel, researchers first had to overcome a major bottleneck limiting the potential for 3D printing high-quality metals, the porosity caused during the laser melting (or fusion) of metal powders that can cause parts to degrade and fracture easily. Researchers addressed this through a density optimization process involving experiments and computer modelling, and by manipulating the materials’ underlying microstructure.

“This microstructure we developed breaks the traditional strength-ductility trade off barrier,” Wang said. “For steel, you want to make it stronger, but you lose ductility essentially; you can’t have...
both. But with 3D printing, we’re able to move this boundary beyond the current trade off.”

Using two different laser powder bed fusion machines, researchers printed thin plates of stainless steel 316L for mechanical testing. The laser melting technique inherently resulted in hierarchical cell-like structures that could be tuned to alter the mechanical properties, researchers said.

“The key was doing all the characterization and looking at the properties we were getting,” said LLNL scientist Alex Hamza, who oversaw production of some additively manufactured components.

“When you additively manufacture 316L it creates an interesting grain structure, sort of like a stained-glass window. The grains are not very small, but the cellular structures and other defects inside the grains that are commonly seen in welding seem to be controlling the properties. This was the discovery. We didn’t set out to make something better than traditional manufacturing; it just worked out that way.”

New material insights

LLNL postdoc researcher Thomas Voisin, a key contributor to the paper, has performed extensive characterizations of 3D printed metals since joining the Lab in 2016. He believes the research could provide new insights on the structure-property relationship of additively manufactured materials.

“Deformation of metals is mainly controlled by how nanoscale defects move and interact in the microstructure,” Voisin said. “Interestingly, we found that this cellular structure acts as a filter, allowing some defects to move freely and thus provide the necessary ductility while blocking some others to provide the strength. Observing these mechanisms and understanding their complexity now allows us to think of new ways to control the mechanical properties of these 3D printed materials.”

Wang said the project benefitted from years of simulation, modeling and experimentation performed at the lab in 3D printing of metals to understand the link between microstructure and mechanical properties. He called stainless steel a “surrogate material” system that could be used for other types of metals.

The eventual goal, he said, is to use high-performance computing to validate and predict future performance of stainless steel, using models to control the underlying microstructure and discover how to make high-performance steels, including the corrosion-resistance. Researchers will then look at employing a similar strategy with other lighter weight alloys that are more brittle and prone to cracking.

The work took several years and required the contributions of the Ames Lab, which did X-ray diffraction to understand material performance; Georgia Tech, which performed modelling to understand how the material could have high strength and high ductility, and Oregon State, which performed characterization and composition analysis.
Lloyd’s Register (LR) has announced the first certification of a part produced through additive manufacturing (AM) for the oil and gas industry. The part, a titanium gateway manifold for pipelines, was designed by Surrey, England-based Safer Plug Company (SPC) and built by the AM production company 3T RPD using powder bed fusion. The entire process was overseen and certified by LR using its framework, an industry first that guides manufacturers on AM processes to certify components.

“In taking on this initiative, LR’s Additive Manufacturing group has truly opened a gateway to the future,” said Ciaran Early, SPC Technical Director. “LR’s pivotal role is to guide suppliers through the codes, standards, controls and best practices to manufacture AM parts, in order that end users will have full confidence that an AM part meets the required level of criticality for that part.”

Year long process

SPC approached LR more than a year previously in order to provide independent assurance of the manifold’s manufacture, due to the innovative process it went through to design and produce it. The manifold is to be included in an assembly for a suite of pipeline isolation tools, which will include the world’s smallest tool suitable for six-inch diameter pipework.

“This project is a great example of how innovative companies are making use of additive manufacturing’s benefits,” said Amelia Stead, LR AM Surveyor and the primary technical lead on the project. “This part would have been nearly impossible to produce using traditional manufacturing techniques due to its complex internal channels.”

LR’s framework, produced alongside The Welding Institute (TWI), takes into account more than material standards. The manufacturing facility was also assessed by the LR team.

“3T RPD are delighted that certification has been issued,” commented Luke Rogers, New Product Introduction Project Manager for 3T RPD. “We regularly work with clients in the aerospace, medical and motorsports industries to produce metal parts. Hopefully SPC will set the example and demonstrate how the oil and gas industry can realise the benefits of AM.”

Going forward, LR will certify the next batch of 10 manifolds produced by SPC and 3T RPD. SPC is now working with LR on a Type Approval certificate which would allow it and 3T RPD to produce the manifolds on demand, as well as the pipeline isolation tools.

Added confidence

“From an industry and customer perspective this certification provides added confidence in parts produced by this new technology,” said Dr. Claire Ruggiero, Director Innovation, Technical and Quality for LR. “This will undoubtedly accelerate the adoption of AM into the oil and gas mainstream. The work we have done with TWI and research undertaken by the LR Foundation-funded PhD students has provided the robust basis for this certification and we look forward to further building our expertise and experience together with the industry pioneers like SPC.”

“It’s crucial that new technologies are embraced by the oil and gas industry,” said Andrew Imrie, LR Global Product Launch Manager. “LR is at the forefront of supporting these new technologies, enabling the industry to bring certified products to market with the proper assurance and confidence.”

LR is involved in several AM projects within the nuclear, marine and construction industries as well. It currently operates three joint-industry projects with TWI which are open to companies who’d like to learn more about the AM process.
Oil and gas companies and duplex manufacturers and suppliers recently defined quality control testing for the purposes of the new ISO 17781 standard. One of the key focuses of these discussions was how to detect infrequent residual intermetallic phases in segregated areas for the superduplex. Aperam contributed to these discussions by conducting a number of experiments that quantified the microstructure’s effect on an offshore application’s susceptibility to hydrogen embrittlement. The results of these studies are presented here.

By Amélie Fanica, Florent Krajcarz and Fiona Ruel, Aperam

Superduplex S32750 is one of the most corrosion resistant grades within the duplex stainless family, making it a competitive alternative material to such nickel-based alloys as 825. Due to a chemical composition of high chromium and molybdenum, super duplex stainless grades are more susceptible to intermetallic phase precipitation, such as σ-phase. As such, particular care must be taken during the entire manufacturing process in order to mitigate deleterious phases precipitation.

Over the last decade, numerous papers have been published on how to best optimise heat treatment conditions in terms of temperature, soaking time, time to transfer from furnace to quenching, cooling rate and stacking in batches. Each of these papers has been further supported by manufacturer feedback, end-user experiences and NORSOK requirements. As a result, our experience with and understanding of duplex grades continues to grow, allowing us to address new questions and concerns.

Most recently, a technical exchange was held between oil and gas companies and duplex manufacturers and suppliers. The objective of these discussions was to collectively define quality control testing and the related requirements needed to finally build the new ISO 17781 standard on ‘Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels’.

One of the key focuses of these discussions was how to detect intermetallic phases caused by both improper heat treatment conditions and segregated areas. During solidification, conventional casting processes may induce a slight

<table>
<thead>
<tr>
<th>Grade</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>“2507”</td>
<td>≤ 0.030</td>
<td>≤ 1.2</td>
<td>≤ 0.035</td>
<td>≤ 0.020</td>
<td>≤ 0.8</td>
<td>24.0</td>
<td>6.0</td>
<td>3.0</td>
<td>0.24</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>S32750</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.0</td>
<td>8.0</td>
<td>5.0</td>
<td>0.32</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Chemical composition (% weight) of “2507” / S32750 according to the ASTM A240

Table 2. Example of super duplex microstructure with segregated area with sigma phase. (NaOH electroetching)
local modification to the chemical composition by solute partitioning. Although this is more or less the case for all metallic alloys, the consequences vary depending on the grade and final application of the alloy. For example, with the super duplex grade, segregated areas which are generally located close to mid-thickness for flat products, contain a higher concentration of both austenite-formers (Ni, N...) and ferrite-formers (Cr, Mo...). This could cause a slight change in phase balance and a localised increase in pitting corrosion resistance. However, the higher chromium and molybdenum contents also make these regions more susceptible to intermetallic phase precipitation, such as \( \sigma \)-phase. Therefore, these phases may be present under the form of the so-called centreline intermetallic stringers, even in cases of proper solution annealing.

As part of the quality control process, it is important to evaluate the effect these centreline intermetallic stringers have on the in-use properties and, more importantly, on hydrogen embrittlement related to the cathodic protection commonly used on subsea systems by the oil and gas sector. For example, super duplex strips can be used as seam welded tubes for umbilicals, offering thickness and weight reductions and high fatigue resistance while using only a limited number of orbital welds. This application requires high chromium and molybdenum to achieve a Pitting Resistant Equivalent Number of 42.5% (PREN=Cr% + 3.3Mo% + 16N%).

The Aperam study
With this in mind, Aperam launched an internal research programme on its super duplex DX2507 (PREN=42.5), which was recently NORSOK qualified for flat product. The research evaluated the effect of the segregated area, with and without intermetallic phases on the hydrogen embrittlement, under simulated cathodic protection in seawater. The results were presented at the Stainless Steel World 2017 conference.

The study started by obtaining a large panel of microstructures on the same 2.1mm thick cold-rolled, solution-annealed sheet. It then selected several appropriate heat treatment conditions, as illustrated in Figure 1.

Each heat treatment condition was then compared to each other and the as-delivered condition. For conditions where only centreline intermetallic stringers were present, four metallographic samples were scanned to search for the ‘worst’ field. A SEM image using the Backscattered Electron Mode to highlight the intermetallic phases in white was taken with a magnification of x800. Thanks to automatic grayscale thresholding, we were able to determine the intermetallic phase fraction on this ‘worst’ field. The average intermetallic phase fraction over full-thickness was then calculated by balancing the field height by sheet thickness (with the assumption that thickness out of the field has a zero-ferrite fraction).

Next, the study measured the remaining ductility level when the material is exposed to cathodic protection in a seawater environment. In-line with the subsea application, tensile samples were exposed in aqueous solution containing 0.5M NaCl at 4°C with a potential of -1100mV (SCE) using Slow Strain Rate Tensile (SSRT) test. This condition roughly simulates cathodic protection by Al-In sacrificial anode in 1000m deep sea water. The first series of SSRT tests was run only in synthetic seawater as a reference and to highlight the possible effects of microstructure.
changes on the mechanical properties. The reduction of area $Z\%$ (i.e. the projected section of the fracture surface divided by the nominal section of the tensile specimen) was measured as an indicator of ductility, the lowest $Z\%$ corresponding to the highest ductility. All drawn tensile curves are very close to each other in the scattering of the tensile test conditions. The exception is the ‘$\sigma$ over full thickness’, which exhibits the lowest ductility level.

For the second series, the simulated cathodic protection was applied and the SSRT test conducted.

**Results**

All results can be expressed using the Reduction of Area Ratio (RAR) to compare the results obtained with and without cathodic protection. The higher the RAR, the lower the susceptibility to hydrogen embrittlement (HE).

On the one hand, we can see that the ‘coarse microstructure’ gives the material the highest susceptibility to HE. On the other hand, we see that ‘coarse’ or ‘light stringers’, as well as ‘free from $\sigma$’, maintain a high-level of ductility. In addition, we didn’t observe any secondary cracks on the edges of the centreline intermetallic stringers. Considering the ‘$\sigma$ over the full thickness’, the RAR is artificially high due to the low reference value.

In conclusion, we observed that, in absence of cathodic protection, duplex with sigma phase over full-thickness (1.8 %) presents the lowest ductility. Under cathodic protection, the performance of duplex with coarse microstructure becomes equivalent to that with $\sigma$-phase over the full thickness. What this means is that the coarse microstructure (austenite spacing of 7.0 µm) is more sensitive to hydrogen embrittlement than duplex with 1.8 % of sigma phase. In parallel to this finding, we saw no effect of centreline intermetallic stringers (up to 0.08% of sigma phase) on hydrogen embrittlement.

This study aimed to highlight the effect of intermetallic phases precipitation in the segregated area and hydrogen embrittlement. These results demonstrate that addressing austenite spacing is of prime importance when dealing with hydrogen embrittlement, and especially its possible presence on intermetallic phases in the segregated area. Secondly, when improper heat treatment conditions imply intermetallic phase precipitation, the hydrogen embrittlement susceptibility will increase accordingly.

The ISO 17781 standard allows one to make the connection between microstructure evaluation and common corrosion testing. Furthermore, using pitting corrosion test allows one to clearly check for the presence of detrimental phases in a much easier way than with SSRT tests.

**About the authors:**

Amélie Fanica is welding engineer graduated (I.W.E.). After working 11 years for Industeel (ArcelorMittal) in the R&D and marketing fields on duplex and clad plate, she joined Aperam in 2016 as business developer for energy and water applications.

Florent Krajcarz holds a Material Science PhD. He has worked as a metallurgist researcher at Aperam Isbergues Research Centre since 2012, where he is in charge of duplex stainless steel metallurgy.
Nitrogen vs argon atomisation of 17-4 PH stainless steel & its effects on AM processing

The choice of atomising gas on the properties of metal powders, in conjunction with the specific additive manufacturing process parameters, plays a key role in the ultimate microstructure and mechanical properties of fabricated parts as demonstrated in this Selective Laser Melting (SLM) study. An inappropriate combination of powder and process can result in the expected final properties of a component not being fully realised.

Text & images from LPW Technology

17-4 PH is a martensitic, precipitation-hardenable stainless steel widely used in aerospace, petroleum, and chemical processing industries. This 17-4 PH alloy utilises a martensitic microstructure infiltrated with fine particles to optimise the mechanical properties. It contains large amounts of chromium, nickel and copper to generate good corrosion resistance and mechanical properties at elevated temperatures (up to 300°C). This material is heat-treatable to increase the hardness, ultimate tensile strength, and yield strength. The typical heat-treatment cycle of 17-4 PH begins with a high temperature austenitisation treatment (1040°C for 3 minutes) to allow super saturation of alloying elements into the matrix. This material is then air cooled to form a martensitic microstructure. Fine, copper-rich particles are precipitated by an age-hardening step (482°C for 1 hour) to improve the alloy’s strength.

Effect of selection of powder atomisation gas and AM process
17-4 PH can be atomised using argon or nitrogen, however, the resulting microstructure of 17-4 PH must be martensitic to deliver the optimum mechanical properties. Atomising 17-4 PH with argon will deliver a powder with the desired martensitic microstructure, whereas nitrogen gas atomisation will deliver an austenitic microstructure. Whether the powder is atomised using argon or nitrogen, subsequent processing of the powder with an argon SLM processing gas will still deliver a martensitic part that can be heat treated to produce enhanced mechanical properties. However, using argon for both atomisation and processing will deliver optimum hardness, ultimate tensile strength, and yield strength values. Using nitrogen for both processes will result in the austenitic microstructure with no observed increase in desired mechanical properties.

The study
17-4 PH powders were created using two different atomisation gases, nitrogen and argon. The chemistries of both powders were within the 17-4 PH specification. Preliminary powder cross sections of the argon atomised powder revealed a martensitic microstructure while the nitrogen atomised powder was austenitic.

Four total builds were completed to study the effect of powder atomisation process and machine environment on the resultant microstructure as shown in Table 1.

Table 1. Test plan and resultant microstructure

<table>
<thead>
<tr>
<th>Build</th>
<th>Powder Atomisation Gas</th>
<th>SLM Processing Environment</th>
<th>Resultant Microstructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Argon</td>
<td>Argon</td>
<td>Martensite</td>
</tr>
<tr>
<td>2</td>
<td>Argon</td>
<td>Nitrogen</td>
<td>Martensite</td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen</td>
<td>Argon</td>
<td>Martensite</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen</td>
<td>Nitrogen</td>
<td>Austenite</td>
</tr>
</tbody>
</table>

Scanning Electron Microscope (SEM) image of LPW-17-4 powder (nitrogen atomised).
All builds that used argon as either the atomisation or SLM processing gas had a martensitic microstructure. The hardness data for these four materials are shown in Table 2. The hardness of the builds with a martensitic structure increased to over 400 HV following heat treatment. However, the build that used nitrogen as the atomisation and processing gas contained a large volume fraction of retained austenite that had no change in hardness.

Nitrogen is a small, interstitial element that, in low concentrations, is soluble in the face centred cubic (FCC) austenite matrix that is normally observed at high temperatures. A study by Biggs and Knutsen suggests that steels with a higher concentration of nitrogen have a higher stacking fault energy which inhibits the nucleation of martensite. This shows that increasing nitrogen concentration, even by small amounts, will reduce the amount of martensite at room temperature and thus affect the heat treatability of the material.

Therefore, when the powder is atomized in a nitrogen atmosphere, and then processed within a nitrogen atmosphere, it is plausible that the nitrogen content increases to the point at which it starts to inhibit the martensite formation. Although the two feedstock materials had only small differences in chemistry, the change in powder production processing route and SLM fabrication conditions resulted in significant differences in the final mechanical properties. This was attributed to different microstructures obtained using different processing routes.

It is clearly important to understand the effect that powder production methods and AM processing parameters can have on the resulting component microstructure. LPW’s highly-trained team understands the behaviour of powders processed under different conditions and can recommend the appropriate powder to achieve the required mechanical properties. LPW can supply both nitrogen and argon atomised 17-4 PH powders.

References:

Table 2. Comparison of material hardness ‘as-built’ and after heat treatment

<table>
<thead>
<tr>
<th>Build</th>
<th>Hardness (as-built) [HV]</th>
<th>Hardness (after HT) [HV]</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>277</td>
<td>424</td>
</tr>
<tr>
<td>2</td>
<td>Not reported</td>
<td>406</td>
</tr>
<tr>
<td>3</td>
<td>292</td>
<td>406</td>
</tr>
<tr>
<td>4</td>
<td>235</td>
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</tr>
</tbody>
</table>

www.stainless-steel-world.net
Rumours of the death of the European Union and of its currency, the Euro, have been greatly exaggerated. After a tough decade the region is finding its feet again and experiencing strong growth. Its stainless steel industry likewise suffered but is recovering slowly. To survive, EU producers must invest in R&D and compete in a global market. Your intrepid correspondent overheard the following conversation during a recent conference, late at night in the bar.

By James Chater
It’s all going to collapse anyway.

What is? The climate? The global financial system?

No, Europe. It’s going to the dogs, right?

Haven’t you heard? Growth is at long last picking up, after years of stagnation following the 2007-8 financial crisis and the Euro debt crisis of 2012. Reform is in the air. Just because a few countries have political or economic problems doesn’t mean the whole EU project is up the spout. It’s a bit of a generalization I know, but on the whole things are improving.

But Europe is—

Please learn to distinguish Europe from the EU. The EU consists of 28 European countries (though it could soon be 27) that pool sovereignty and funds to create a political and economic block. Then there are the free trade areas which allow trading relationships with other European countries that aren’t in the EU, for instance Norway and Switzerland.

Sounds complicated.

It is. But to get back to your point about things “collapsing”: naturally, in a region that is so brimming with history and diversity, there are occasional crises and outbreaks of, er – over-excitement.

It’s all about money, isn’t it?

It’s also a political project. Laws are passed that protect workers’ rights, the environment, health and safety, standards, consumers’ rights and so on. Doesn’t that just make everything more expensive?

Sharing standards and regulations instead of each country having its own saves everyone time and costs. And look how many non-EU countries want to do business with us: we already trade with many countries, and now we are making trade deals with Japan and Canada.

(Taking out the sheet bearing table 1) Here, take a look at this.

(looking at the table) Hmm. If Germany is the economic engine of Europe, why has its stainless steel production declined so drastically?

In 2011 Thyssen Krupp, reeling from the financial crisis, sold off some of its assets. It spun off its stainless steel production assets as Inoxum, which it then sold to Outokumpu. This may partially explain Germany’s decline as a stainless producer. But three years later TK acquired Italian producer Acciai Speciali Terni, which supplied the parent company with primary products which it then redistributes or turns into washing machines, turbines and the like. So Germany’s apparent “decline” is simply a shift to added-value activities such as fabrication and engineering. Germany is a major exporter of consumer and industrial goods.

The same can be said of Europe’s engineering industry in general: Technip (oil and gas), Veolia (water), Siemens and Wärtsilä (power generation), Alfa Laval and Tranter (heat exchangers) —

Quite. But to get back to primary production: Europe’s number 1 producer and consumer seems to be Italy. The country has quite a love affair with stainless steel, and the industrial north is studded with small

Table 1. Stainless steel melt shop steel production (000 metric tons) (1)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<td>1,298</td>
<td>1,388</td>
<td>-</td>
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Zhejiang Satellite Energy selected Siemens to provide a reactor effluent compressor train for its propane dehydrogenation (PDH) plant in Pinghu City, China. The dual-casing compressor train consists of two Siemens STC-SH single-shaft compressors driven by a Siemens SGT-750 industrial gas turbine. Plant commissioning is scheduled for early 2019.

and medium-size primary producers and tube manufacturers. Stainless is everywhere in Italy’s city centres: all those bars, buildings, bus shelters, sculptures... Also, its food industry and LNG terminals, not to mention its oil & gas industry, consume large amounts of stainless. Other significant producers include Spain, which increased its production between 2010 and 2016, Belgium, Sweden and Finland.

E But it’s all chickenfeed compared to China.

U For once I have to agree with you. EU production figures for the first nine months of 2017 show an increase of 1.7% year on year, but this was trumped, if I may use this word, by the USA’s whopping 14.8%, dwarfing also China (8.8%) and Asia without China or South Korea (4.2%). The world average increase was 7.4%. And of course China has been increasing market share year by year (Table 2). The EU’s share halved in 11 years.

Table 2. Regional percentage share of stainless steel production (2)

<table>
<thead>
<tr>
<th>Region</th>
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<tr>
<td>Americas</td>
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<td>Asia excluding China</td>
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generate cash each year since its creation in 2010. Several companies have emerged from these processes in good shape, and if the world economy continues to grow (touch wood) they should do well. Sandvik, the Swedish company producer of mining and cutting tools, tubes and pipes, powder metals and welding materials in titanium and stainless steel, went through a difficult period in the early 2000s, but is now in the black after extensive restructuring and cost savings. A star performer has been Spain’s Acerinox, which in terms of profit has been going from strength to strength. It ended the first half of 2017 with the best half-yearly balance of the decade and has been expanding. So has Austria’s Voestalpine, which is building a new steel plant in Kapfenberg, Austria. This producer of special steels, powder materials, nickel-based alloys and titanium, which lately announced healthy earning figures, is a major supplier to the aerospace and auto industries. Another rapidly expanding
company is Italy’s Marcegaglia, maker of plates and welded tubes in carbon and stainless steel with an extensive global reach. Several companies are innovating: Sandvik pioneers new materials and filler wires for welding, and has offered several new super- and hyper-duplex grades for the offshore and petrochemical industries and for the marine industries. Outokumpu has likewise expanded its duplex offerings, with new lean grades for the construction and desalination industries.

**E** Europe consumes a greater share of duplex than any other region.

**U** Correct. Duplex grades allow thinner gauges to be applied, thereby saving on weight and costs.

**E** What about other innovations?

**U** There are plenty. Industeel (part of Arcelor-Mittal) has been developing ferritic grades for auto exhaust systems. Sandvik is a leading pioneer in super-austenitics and has invested extensively in powder metallurgy. Several companies (Sandvik, Voestalpine, Thyssen Krupp, Siemens, BMW) are branching into 3D manufacturing, and the German and British governments are supporting several such initiatives. A UK company, Metalysis, has been developing solid-state metal powder manufacturing technology to produce alloys in a more environmentally friendly way.

**E** You mentioned “added value” just now. What about stainless tube and pipe?

**U** A very good example! The EU has lots of specialized producers who export all over the globe. Vallourec has started to supply umbilicals to the offshore oil and gas industry from its recently completed factory in Burgundy, France. It has pioneered better ways to produce welded tubes for the nuclear, desalination and process industries and has contributed to a long-term shift from seamless to welded tubes. Its reach is global, with factories in Brazil, China, USA, S. Korea and India. Tubacex was affected by the oil and gas slump, but adapted by increasing sales to other sectors, especially power generation. In 2016 it made a well timed move into Asian markets, with acquisitions and takeovers. Mannesmann Stainless Tubes specializes in seamless stainless steel and nickel-alloy tubes and pipes and is active across the whole gamut of process and energy industries. It has gained particular expertise in shot-peening for superheater and reheater tubes. The Schulz Group, makers of welded and seamless pipes and fittings, is headquartered in Krefeld, Germany, but has manufacturing plants in Brazil and the USA. It has just been acquired by the Berkshire Hathaway’s Precision Castparts. And we should not forget traders, such as Van Leeuwen, and the more specialized producers such as Butting, maker of vessels and clad tubes and pipes for the energy and process industries; and Fine Tubes and Superior Tubes, both suppliers to the aerospace industry.

**E** The aerospace business has been in the news recently, in connection with the UK’s intention to quit the EU.

**U** Aerospace and auto are good examples of industries that have come...
to rely on unimpeded cross-border movement. Manufacturing processes have become so specialized that components can cross national borders several times before being integrated into the final product. Brexit has highlighted this benefit in a negative way: imagine what it will be like if all these components have to go through customs each time! Airbus has said it may have to move manufacture to another EU country. Rolls-Royce, on the other hand, has pledged to stay in the UK even though it is struggling with a weaker pound.

E Yes, and the tariffs the USA is slapping on Bombardier don’t exactly help, either.

U The EU aerospace industry has other problems too. Airbus may have a large order backlog, but its profits are falling because of production delays and issues with engines. Also, sales of the jumbo A380 have plummeted as operators turn to more fuel-efficient long-haul planes. Still, the long-term prospects for aerospace are pretty good, and suppliers will benefit from future repeat orders for parts of the aircraft currently in service or in production. This is why they are investing in 3D manufacture.

E What about other industries?

U I already mentioned auto, and cars will consume more and more stainless in the future. In this sector too, UK sales are being dragged down by Brexit uncertainty, but in Europe as a whole car sales are up after six years of decline. Every few years emissions regulations are tightened, creating demand for lighter vehicles incorporating materials with better strength to weight ratios. This means stainless steel is increasingly used in both structural and cosmetic applications.

E This also applies to buses and trains, surely?

U Yes, and you see producers like Stalatube developing lighter materials – ferritic and lean duplex grades – for bus bodies.

E I’m told the auto industry accounts for 13% of European stainless steel sales.

U That’s right. The other sales go on consumer goods and health care (40%), chemical, petrochemical and energy (19%), and construction and infrastructure (16%) (3).

E What do you think are the growth areas for stainless steel?

U The industrial hotspots will continue to be important: the North Sea offshore industry, Germany’s Ruhr valley, the gigantic industrial complexes of Rotterdam and Antwerp, northern Italy, northern Spain, Poland… One sector where you won’t see much growth is fossil fuel power. Instead, look for opportunities in renewables, biofuels, LNG, and nuclear. And let’s not forget the many oil and gas companies that operate all over the world: BP, Eni, Shell, Statoil, and Total.

E How can stainless producers best meet future challenges?

U I think they’re on the right track. They have consolidated and gone global. A major task will be to strengthen R&D activities in order to keep up with China, which is aiming to become a major scientific power. But there is still time – China has a way to go.

I think we can also expect strong growth from the eastern part of the EU. Poland is growing rapidly, and its auto, mining, coal and agricultural sectors surely provide opportunities.

E Here’s to opportunity!

U I’ll drink to that.

U and E (toasting)

Cheers! Cin cin! Prost! Santé! Topa! Gezondheid! Na zdrowie!

References

Shielding gas & purging techniques during welding

Part 4: Minimising $O_2$ and use of monitoring equipment

In parts 1-3 the author outlined the problems in selecting the optimum purge gas and technique, as well as protective enclosures and trailing shields. In this final article he explains that using specialised weld purging equipment does not guarantee defect free welds; controlling the oxygen content of the purge gas is crucial to success.

By Dr. Mike Fletcher

In this final part of the series the significance of maintaining a low level of oxygen in the purge gas is considered. Several factors will determine what oxygen content can be tolerated in order to prevent oxidation, the most crucial of which is the material being welded. Sensitive alloys such as titanium may require oxygen to be limited to 50 ppm whilst some stainless steels will tolerate 150 ppm without noticeable surface discolouration.

The first crucial step which is often overlooked is providing effective sealing around the weld zone. Poor sealing allows air to enter the weld zone and thus defeats the objective of providing a low $O_2$ environment. Attention needs to be given then to sealing any contiguous surfaces. These include services providing gas and other accessories, contact with the material being welded when using pipe purging and trailing shields and, in the case of enclosures, operator access points. Engineered solutions exploit established technology to achieve reliable solutions to sealing.

Monitoring $O_2$ content
Weld discoloration caused by the presence of $O_2$ in the purge gas may well be acceptable under some circumstances, but the mechanical and metallurgical properties of the joint can be compromised and this can lead to weld failures in service. Rather than risk weld contamination, measurement and control of purge gas $O_2$ content during the welding cycle is the recommended approach. Oxygen measuring devices have been available for many years, but standard instruments based on primitive technology are totally unsuitable for weld purge gas monitoring. This is especially so in a wide range of industry sectors where the demand for lower $O_2$ levels has been increasing over the past few years.

A decade ago an $O_2$ content below 0.1% (1000 ppm) in purge gas was considered low enough for all but the most demanding applications. Not anymore. Quality control during semiconductor, food, beverage, petrochemical and aerospace manufacture has increased awareness of the need to reduce particulate contamination such as might arise from poor weld underbead regulation. Research has also shown that even very low residual oxygen levels can result directly in significant reduction in corrosion resistance in some materials. The net effect of all this evidence has been to reduce acceptable oxygen levels in some circumstances to well below 0.001% (10 ppm). Accompanying this trend is a demand for measuring instruments to be more robust and reliable.

Monitoring equipment design
Early equipment was based on the ‘wet cell’ technology developed to meet routine needs to measure $O_2$ contents of 10% or more in air. Many such devices are still marketed for welding applications but the sensing limits are not much below 100 ppm and even that is unreliable. As long ago as 1990 it was recognised that major changes in instrumentation would be required to meet the increasing demand for sensitivity, reliability and robustness. Taking advantage of technological and engineering developments a range of instruments has emerged using zirconia as a sensing device.

Early products satisfied the immediate requirements for welding, but subsequent changes in demand led to the availability of instruments now capable of meeting the most stringent conditions. Despite the clear evidence that better equipment was needed, some welding suppliers still offer unsuitable products on the international market. Most of these are based on multi-gas analysers developed for the security and chemical industries. They do not have the oxygen sensitivity required for weld purge gas analysis.

Figure 1. Examples of effective sealing arrangements for, from left to right, inflatable pipe welding system, silicone skirt on trailing shield and glove ports on enclosure.
For routine welding of the majority of stainless steels there is a requirement for the purge gas to contain less than 0.01% oxygen. More sensitive materials such as titanium alloys and some special stainless steels, particularly when used by the semiconductor industry, may require oxygen levels well below 0.01% 2.

A basic monitor from Huntingdon Fusion Techniques has been developed to meet the role of providing a rapid and accurate reading of oxygen in the purge gas in a compact and robust instrument rugged enough to be suitable for on-site application. It can be used as a continuously reading instrument with free flow of the purge exhaust gas across the sensor or as a sampling instrument with the hand vacuum pump extracting samples from the purged volume, as and when desired.

For more demanding measurements, specialised models have been introduced. These have a measuring range that goes down below 10 parts per million.

The Argweld ‘PurgEye’ range is representative of advanced monitors now available. This series of instruments was the result of several years’ development and fully exploits both scientific and engineering knowledge. Designed specifically for the welding industry the PurgEye range satisfies the requirements for sensitivity and accuracy whilst at the same time offering reliability and ruggedness.

A second generation of monitors has been designed to meet the requirements for welding of high specification stainless steels, duplex steels, titanium and other reactive alloys. They have a measurement range from 1000 to 10 ppm. The recording and auditing capabilities of these advanced weld purge monitors are considered vital to the tube and pipe sector where traceability is now becoming a critical issue. Quality management printout is available. Integrated automatic alarm provides signalling and switching in the event of oxygen levels in the purge gas rising above an operator-set level.

Further development has witnessed the introduction of integral gas sampling pumps for applications where there may be insufficient flow of exhaust purge gas. These also featured advanced electrical shielding to avoid HF/RF interference. Situations can arise when welding joints where physical access for monitoring is impractical such as in long tube and pipe fabrications or where a temperature cycle may be outside the range of monitoring instruments. This has led to the development of a remote sensing head that can be fitted onto the purging system and will measure oxygen level in the purge gas and transmit the information electronically to the monitor up to 1 km away.

Many advanced purge monitors now incorporate a networking facility to integrate with a range of accessories to control welding processes from the monitor controller. For example, automatic machines such as orbital welders can be switched on and off automatically by the monitor to meet operator pre-set oxygen levels.

References
1. Oxygen content may be measured as a percentage or as parts per million (ppm). The relationship is linear and as an illustration, 0.01% = 100 ppm.
3. Zirconia–based sensors are robust solid-state devices unaffected by position and with no real limitation on shelf life or storage temperature. They are thus well suited for site applications.
Restructuring & upgrading China’s industry

After a period of enduring outdated production facility closures, pressures from stricter environmental rules, more stringent delivery requirements, panic over raw material prices and international trade barriers, the Chinese stainless industry is now restructuring and upgrading to a higher level. Stainless Steel World spoke to Mr. Luo Kunjie, Senior Engineer at Suzhou Nuclear Power Research Institute for an update on the situation.

By ZHU Yixing (Jewel), Stainless Steel World, China

Production and consumption of stainless steel

In 2017 China’s annual production of stainless steel was around 28,000,000 tons, an increase of 3.5% on the previous year. Of the global gross production of 50,000,000 tons, China accounted for 52%, maintaining their top ranking throughout the world. Consumption of stainless steel in China currently stands at around 20,000,000 tons, an increase of 5.9% on the preceding year. Because end users had lower stock levels than they held the year before, the true consumption by end users ended up being similar to predictions. China also ranks top on the world’s consumption list.

Changes to stainless steel industry structure

In 2017 the structure of the Chinese stainless steel industry experienced a transition point during which the production of 200 series steel decreased while the 300 series increased, indicating that consumption of higher grade material is on the increase. The second big trend relates to the production of duplex which exceeded 100,000 tons giving an increase of 12.4%. The production of super duplex also increased, predicting the changes in industry structure.

Stricter environmental policies

Beginning in 2015 with the new environmental legislation, in 2017 further, more stringent environmental protection policies came into force in order to restrict pollution. From January 1st 2017, China came up with new “Environmental Protection Laws”, resulting in the domestic steel industry facing the huge challenge of shutting down old factories and updating manufacturing facilities. The strict new regulations and laws are forcing the industry to upgrade and grow.

Export challenges versus increased imports

The export of stainless steel was 400,000 tons in 2017 with a likely increase of 2.9% by 2018. The import of stainless steel increased by 63% to 120,000 tons. Due to the ‘Belt and Road Initiative’ strategy, there are some manufacturers investing in southeast Asia where they have local production facilities, then shipping the product back to China. However, explains Mr. Luo, “in parallel with the overcapacity situation in the domestic market, the ‘Belt and Road Initiative’ strategy is encouraging more Chinese end users and EPCs to invest abroad to take advantage of the overcapacity situation.” He continues; “the demand for super duplex and special materials such as nickel alloys and super austenitic stainless steel is still there. But with the rapid improvement of the domestic material manufacture, the leading stainless steel manufacturers in China are as competitive as the international brands.”

Raw material price influence

The raw material price was volatile in 2017. The price of nickel rose sharply from 65,000 RMB to 118,000 RMB per ton. The knock on effect of price changes led to increases in the price of 304 stainless steel together with other grades. Traditionally, the price is mainly influenced by the cost of raw materials and the cost of production. In 2017, however, the financial industry forecast assigned material manufacturers a more important role.

New applications for Chinese stainless steel

Mr. Luo, “Market consumption remains the biggest influence on Chinese stainless steel producers. I think the oil & gas industry is still the largest industrial consumer of stainless steel, although the power industry also consumes a lot. The 610°C-700°C super-austenitic stainless steel for key parts of ultra-supercritical generator projects achieved a remarkable level. The demand for new, energy efficient vehicles will increase which will result in an increased use of nickel. The medical industry is also a field showing a lot of potential, for example in the application of artificial joints, etc. Artificial Intelligence may also call on the stainless steel manufacturing industry.”

Note: some of the data is quoted from the Stainless Steel Council of China Special Steel Enterprises Association 2017 annual report.
APD to supply industrial gases

Air Products (APD) has signed an agreement with a subsidiary of Shanxi Jincheng Anthracite Coal Mining Group for the supply of industrial gases to Phase One of Shanxi Jinmei Huayu Coal Chemical Co Ltd.’s (Jinmei Huayu’s) coal-to-clean-fuels project in Jincheng City, Shanxi Province.

Previously, Air Products signed a sale of equipment agreement with Jinmei Huayu to supply two air separation units (ASUs)—with a total capacity of over 4,000 tons per day—for this project, which uses coal to produce clean fuels.

Now, Air Products intends to buy back the two ASUs for approximately USD 100M and supply industrial gases via pipelines to Jinmei Huayu under a long-term supply agreement, subject to finalization of a buy-back agreement and any government and regulatory approvals. The ASUs are expected to be onstream in mid-2018.

Messer signs gas supply contracts

Messer has concluded two new pipeline gas supply contracts in the Chinese city of Chongqing. The new customers are a chemical company and a transformer manufacturer. The gas supply contract between Messer and the chemical company Chongqing Feihua Environmental Science & Technology (FEST) was concluded. The company has been receiving oxygen, nitrogen and purified air from Messer since mid-2017. The gases are supplied through a pipeline system since both parties are located in the immediate vicinity on the chemical park. The gases are being used in the production of chlorine gas, which FEST supplies to BASF, as a raw material for the production of hydrogen chloride.

Also, Messer has gained Wangbian as a new customer. The transformer manufacturer gets gaseous nitrogen from Messer.

TISCO project wins award

The 2016-2017 National Quality Engineering award ceremony, sponsored by China Association of Construction Enterprise Management, was held in Beijing Great Hall of the People on December 13. TISCO’s stainless steel cold tandem rolling revamping project won the award.

The project, completed and put into production in June 2014, is the twelfth five-year key project of Shanxi Province. At the beginning of the project preparation, TISCO put forward the goal to achieve the national quality award. For this purpose, TISCO came up with an engineering design based on the principle of main equipment manufactured and assembled domestically with key parts imported from abroad. The project has significantly improved the production efficiency and the quality level of TISCO stainless steel products with emission index reaching the international advanced level for comprehensive energy consumption of per ton steel reduced by 6.58% and the energy recovery increased by 6.8%.

Through the project TISCO can produce a series of high-end stainless steel materials applied in various industries.

Gazprom, CNPC sign new agreement

A working meeting between Alexey Miller, Chairman of the Gazprom Management Committee, and Wang Yilin, Chairman of the Board of Directors of CNPC, was held recently.

Highlighting the successes of their partnership in the gas sector, the parties noted the progress made in the implementation of the project for Russian gas exports to China via the eastern route. Negotiations continue over the planned supplies from Russia’s Far East. In addition, the companies carry on with their active collaboration in such areas as underground gas storage, gas-fired power generation, and the use of gas as a vehicle fuel.

After the meeting, Alexey Miller and Wang Yilin signed the Heads of Agreement for natural gas to be supplied from Russia’s Far East to China. The document outlines the basic parameters of future supplies, namely the volumes, the term of the contract, the starting date of supplies, the surge period, and the cross-border point.

The parties also signed the coordination agreement – the addendum to the sales and purchase agreement for gas to be supplied via the eastern route.

ZKIN receives strategic investment

ZK International Group Co., Ltd. (ZKIN) has received a strategic investment from NGST Limited, which is owned by Antanas Guoga and Exigent Capital, a firm specializing in cryptocurrency trading.

ZKIN completed a closing of a private placement offering of restricted ordinary shares of the Company, at a purchase price of USD 6.00 per share, for an aggregate purchase price of USD 520,000. Upon the closing, the Company issued a total of 86,666 restricted ordinary shares to the investors in the Offering, subject to customary restrictions pursuant to Rule 144 of the Securities Act of 1933.

The Shares were offered and sold to both investors in the offering pursuant to certain subscription agreements entered into on December 28, 2017.
Wison delivers FSRU to Exmar

Wison Offshore & Marine (Wison) has completed final delivery of the world’s first barge-based floating LNG storage and re-gasification unit (FSRU) to Belgian company Exmar. The recipient company has confirmed that long-term employment for the FSRU starting from mid-2018 has been secured.

The FSRU barge constructed at Wison Nantong shipyard features an LNG storage capacity of 25,000m³ and a re-gasification capacity of 600MMSCFD. It is the first ever FSRU project undertaken by a Chinese company on an EPC basis. A modularized approach helped shorten the schedule and lowered the risks associated in the construction phase, while a dedicated cargo handling system for the SPB tanks has been developed. This barge-based FSRU serves as a flexible LNG receiving solution, which reduces CapEx and lead time possible for project developers.

Danieli Corus receives orders from China

Huai’an Special Steel Co. Ltd. and Hebei Jingye Iron and Steel Co. Ltd. have selected Danieli Corus for the design, supply and installation supervision of Sublance-Based Process Control Systems for their BOF steelmaking plants. Huai’an Special Steel is part of the Shagang Group. In recent years, Shagang Group has purchased multiple BOF Process Control Systems from Danieli Corus, including one to replace an underperforming system from a competing European supplier. The system for Hebei Jingye will be implemented at all three of the 180 converters of their No. 2 steelmaking plant. These orders bring the total number of Danieli Corus Sublance Systems to 127, of which 79 installed.

Sunpower bags a RMB 41.5M contract

Sunpower Group Ltd. (Sunpower) has announced that its wholly-owned subsidiary, Jiangsu Sunpower Technology Co., Ltd. (Sunpower Technology) has signed an EPC contract worth RMB 41.5M with Xinjiang GCL New Energy Material Technology Co., Ltd. (Xinjiang GCL). Upon delivery of the contract, Sunpower expects a positive impact on its FY2018 results. Xinjiang GCL is a subsidiary of GCL-Poly Energy Holdings Limited (GCL). As part of the contract, the Group will be providing Engineering, Procurement and Construction (EPC) services to Xinjiang GCL’s wastewater treatment and Zero-Liquid-Discharge (ZLD) facility for Phase I of its polysilicon project, which has an annual production capacity of 60,000T. This is also the second contract awarded by GCL to the Group this year following an equipment supply contract awarded in May 2017. The industrial wastewater treatment and ZLD industry saw a growth in 2016 and has become an integral part of China’s environmental protection initiatives to combat pollution.

Stainless Steel in China

China produced 54% of all stainless in 2017*

+3.5% production 2016-2017

26,000,000 tons produced in China in 2017

100,000 tons of duplex produced in 2017

Melt shop production (ingot/slab equiv.) in 1,000 metric tones

The glass and stainless clad Shanghai Tower is the tallest building in the world @632m

Sources: *ISSF, Wikipedia, Gensler

www.stainless-steel-world.net
718 NICKEL ALLOYS

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Plymouth PL6 7LG
United Kingdom
tel: +44-1752-733301
sales@fine-tubes.co.uk
www.finetubes.com

Ratnamani Metals &
Tubes Ltd
17, Rajmugat Society
Naranpura Cross Road
Ahmedabad - 380 013
Gujarat,
India
tel: +91-79-2741-5501
fax: +91-79-2748-0999
info@ratnamani.com
www.ratnamani.com

TITANIUM SEAMLESS TUBES

TANTALUM

Marphil International
36, Rue de Richelieu
F-75001 Paris
France
tel: +33-1-42-97-44-74
fax: +33-1-42-96-27-18
marphil.int@wanadoo.fr

TITANIUM

Alloy Wire International
Narrowboat Way,
Hurst Business Park,
Brierty Hill
West Midlands,
DYS 1UF
United Kingdom
tel: +44-1384-262-022
fax: +44-1384-263-022
sales@alloywire.com
www.alloywire.com

ACNIS® International
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F-69100 Villeurbanne
France
tel: +33-472-1455-00
fax: +33-472-1455-09
contact@acnis-titanium.com
www.acnis-titanium.com
(continued)

HARALD PIHL England
tel: +44 1902 833 839
fax: +44 1902 462 001
info@haraldpihl.com

HARALD PIHL Norway
tel: +47 90 20 40 40
fax: +46 8 731 05 40
info@haraldpihl.no

HARALD PIHL is Europe’s fastest supplier of Nickel alloys and Titanium. Updated stock list at: www.haraldpihl.com

Officine Orsi SpA
Villaggio Francofino
I-20080 Caspiano (MI)
Italy
tel: +39-02-9850-951
fax: +39-02-9815-452
info@officineorsi.com
www.officineorsi.com
Manufacturer since
1954 of pipes and fittings in Ti gr.1, gr.2, gr.7 and Nickel Alloys

Tipro International Co., Ltd
D-3104. Van Metropolis,
Tangany Road,
Xi’an
710065
China
tel: +86 29 89181603
fax: +86 29 89181665
sales@tiipro-international.com
www.tipro-international.com

TITALIA S.P.A.
Via Don Luigi,
10081
Brugherio MB
Italy
tel: +39 039 882759
fax: +39 039 5969933
titalia@titalia.it
www.titalia.it
Dealing in titanium bars, plates, sheets, coils, welding wire, flanges, forgings products acc. to dwg.

Tool Peaks Industries Limited,
Xuyi Titan and Materials Co., Ltd
Room 408,420 Tower C,
TEMPO Mansion,
No 115, Sha Zhou Road (West),
Zhangjiagang City
215600 Jiangsu
China
tel: +86 512 58226763
fax: +86 512 58222714
terry@xuyititan.com
www.xuyititan.com

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fax: +46 8 731 05 40
info@haraldpihl.se
www.haraldpihl.com
ISO 9001 certified since 1997
AS/EN 9120 certified since 2013

HARALD PIHL Finland
tel: +358 20 749 7040
fax: +358 20 749 7049
info@haraldpihl.fi
www.haraldpihl.com

HARALD PIHL Germany
tel: +49 2161 87 54 00
fax: +49 2161 57 598-0
info@haraldpihl.com

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<th>Country</th>
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<tr>
<td>ACNIS International</td>
<td>France</td>
<td>+33-472-1455-00</td>
</tr>
<tr>
<td>AEROMETALS &amp; ALLOYS</td>
<td>France</td>
<td>+31-161 03 03 90</td>
</tr>
<tr>
<td>Alloy Wire International</td>
<td>UK</td>
<td>+44-1384-566-775</td>
</tr>
<tr>
<td>ARCEO Engineering</td>
<td>Belgium</td>
<td>+32-4 236 96 32</td>
</tr>
<tr>
<td>Arcos Industries, LLC</td>
<td>USA</td>
<td>+1-800-233-8460</td>
</tr>
<tr>
<td>Bercellesi BERINOX s.r.l.</td>
<td>Italy</td>
<td>+39 02 98231072</td>
</tr>
<tr>
<td>Blacoh Metal Solutions</td>
<td>USA</td>
<td>+1-800-603-7867</td>
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<tr>
<td>BRISMET</td>
<td>USA</td>
<td>+1-423-989-4870</td>
</tr>
<tr>
<td>BUTTING</td>
<td>Germany</td>
<td>+49-5834-50-0</td>
</tr>
<tr>
<td>Cangzhou KH Fittings Corp.</td>
<td>China</td>
<td>+86-317-5533029</td>
</tr>
<tr>
<td>Chun &amp; Vollerin s.r.l.</td>
<td>Italy</td>
<td>+39-02-488-8291</td>
</tr>
<tr>
<td>Corrotherm International Ltd.</td>
<td>UK</td>
<td>+44-238-0-748-100</td>
</tr>
<tr>
<td>Energy Metals Inc, USA</td>
<td>USA</td>
<td>+1-713-790-0222</td>
</tr>
<tr>
<td>Euracciai s.r.l.</td>
<td>Italy</td>
<td>+39 0248 704428</td>
</tr>
<tr>
<td>Fine Tubes Ltd. UK</td>
<td>UK</td>
<td>+44-1752-735851</td>
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<tr>
<td>Froch Enterprise Co., Ltd.</td>
<td>Taiwan</td>
<td>+886-5-5571669</td>
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<tr>
<td>HARALD PIHL UK</td>
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<td>+44 1902 833 839</td>
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<td>HARALD PIHL Finland</td>
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<td>+358 20 749 7040</td>
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<td>HARALD PIHL Germany</td>
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<td>+49 2161 57 598-0</td>
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<td>+48 798 700 388</td>
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<td>HARALD PIHL Sweden</td>
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<td>+46 8 731 56 00</td>
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<tr>
<td>Hart b.v., the Netherlands</td>
<td></td>
<td>+31-33-245-3848</td>
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<tr>
<td>Hempel Special Metals GmbH.</td>
<td>Germany</td>
<td>+49-208-6204-0</td>
</tr>
<tr>
<td>ID Alloys</td>
<td>France</td>
<td>+33-364 198 164</td>
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<tr>
<td>INVEX AB, Sweden</td>
<td>+46 31 57 77 90</td>
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<td>Italbond SpA, Italy</td>
<td>+39-030-682-9911</td>
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<tr>
<td>JIULI Hi-Tech Metals, China</td>
<td></td>
<td>+86-572-2539776</td>
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<td>Kobelco Steel Tube Co., Ltd.</td>
<td>Japan</td>
<td>+81-3-5739-5051</td>
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<tr>
<td>KÖNIG + CO. Gmbh, Germany</td>
<td></td>
<td>+49-2738-601-0</td>
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<td>Kuze Bellows Kogyosho Co Ltd, Japan.</td>
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<td>Lovere Bilbao I., S.L., Spain</td>
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<td>+34-844-454 5130</td>
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<tr>
<td>Mannesmann Stainless Tubes GmbH, Germany</td>
<td></td>
<td>+49-208-458-01</td>
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<td>Marphil International, France</td>
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<td>+33-1-42-97-44-74</td>
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<td>Merinox B.V. the Netherlands</td>
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<td>+31-78-197800</td>
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<tr>
<td>Messe Düsseldorf GmbH, Germany</td>
<td></td>
<td>+49-211-4560-779</td>
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<tr>
<td>Nippon Steel &amp; Sumitomo Metal Corporation, Japan</td>
<td>Japan</td>
<td>+81-3-6867-5788</td>
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<tr>
<td>Nippon Yakin Kogyo Co Ltd, Japan</td>
<td></td>
<td>+81-3-3273-4649</td>
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<tr>
<td>NSSC(Nippon Steel &amp; Sumikin Stainless), Japan</td>
<td></td>
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<tr>
<td>Officine Orsi SpA, Italy</td>
<td></td>
<td>+39-02-9850-951</td>
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<tr>
<td>P.A. Inc., USA</td>
<td></td>
<td>+1-713-570-4900</td>
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<tr>
<td>Paul Meijering Metalen BV, The Netherlands</td>
<td></td>
<td>+31-418-750-600</td>
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<tr>
<td>Productos Tubulares S.A.U, Spain</td>
<td></td>
<td>+34-94-495-5011</td>
</tr>
<tr>
<td>Q-Metal, Denmark</td>
<td></td>
<td>+45 48 86 2622</td>
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<tr>
<td>Raccortubi s.p.a., Italy</td>
<td></td>
<td>+39-029-76300-1</td>
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<tr>
<td>Ratnamani Metals &amp; Tubes Ltd, India</td>
<td></td>
<td>+91-79-2741-5501</td>
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<tr>
<td>Sandvik Materials Technology, Sweden</td>
<td></td>
<td>+46-26-263000</td>
</tr>
<tr>
<td>Sankyo &amp; Co., Ltd., Japan</td>
<td></td>
<td>+81-3-5929-1981</td>
</tr>
<tr>
<td>Shanghai Baoluo Stainless Steel Tube Co., Ltd.</td>
<td>China</td>
<td>+86-21-27540720</td>
</tr>
<tr>
<td>S &amp; N Stainless Pipeline Products Ltd,</td>
<td>UK</td>
<td>+44-161-728-1148</td>
</tr>
<tr>
<td>SpecialSteel Stock - (C.S.C. SpA.), Italy</td>
<td></td>
<td>+39-0445-579286</td>
</tr>
<tr>
<td>Statalube Oy, Finland</td>
<td></td>
<td>+358-3-882190</td>
</tr>
<tr>
<td>Steel Dynamics Limited, UK</td>
<td></td>
<td>+44-1204-368600</td>
</tr>
<tr>
<td>Superior Tube Company, USA</td>
<td></td>
<td>+1-610-489-5200</td>
</tr>
<tr>
<td>Suraj Limited, India,</td>
<td></td>
<td>+91-79-27540720</td>
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<tr>
<td>Teuling Staal, the Netherlands</td>
<td></td>
<td>+31-78-6293340</td>
</tr>
<tr>
<td>Tipro International Co., Ltd, China</td>
<td></td>
<td>+86 29 89181603</td>
</tr>
<tr>
<td>TITALIA SPA, Italy</td>
<td></td>
<td>+39-039-882759</td>
</tr>
<tr>
<td>Tool Peaks Industries Limited,</td>
<td></td>
<td>+86-512-58226763</td>
</tr>
<tr>
<td>Xuyi Titan and Materials Co., Ltd, China</td>
<td></td>
<td>+86-512-58226763</td>
</tr>
<tr>
<td>Tubacex Tubos Inoxidables sa, Spain</td>
<td></td>
<td>+34-94-671-9300</td>
</tr>
<tr>
<td>Yongxing Special Stainless Steel Co., Ltd., P.R. China</td>
<td></td>
<td>+86 572 2768671</td>
</tr>
<tr>
<td>ZM TUBES ZWAHLEN &amp; MAYR S.A., Switzerland</td>
<td></td>
<td>+41-24-468-4646</td>
</tr>
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|--------------|-----------|----------------------|-----------|-------------|----------|---------|-----------------|------|---------|---------|--------|---------|--------|--------|--------|-----------------|----------------|---------------|------|------------|--------------|--------|------------|------------|
| ACNIS International |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Aerodyne Alloys LLC |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| AEROMETALS & ALLOYS |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| AHT Stainless Tube Co., Ltd. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| ARCEO Engineering |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Bercellesi BERINOX s.r.l. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| BRISMET |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Brown McFarlane |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| BUTTING |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Cangzhou KH Fittings Corp |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Castle Metals |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Corrotherm International Ltd. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Energy Metals Inc. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Fine Tubes Ltd. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| HARALD PIHL |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Hempel Special Metals GmbH |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| ID Alloys |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| INVEX AB |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Italfond SpA |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| KÖNIG + CO. GmbH |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Lovere Bilbao I., S.L. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Mannesmann Stainless Tubes GmbH |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Merinox B.V. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Metalfin Limited |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Nippon Steel & Sumitomo Metal Corporation |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| P.A. Inc. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| PM International Suppliers, LLC |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Productos Tubulares S.A.U |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Raccortubi S.p.A. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Ratnamani Metals & Tubes Ltd |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Sandvik Materials Technology |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Shanghai Baoluo Stainless Steel Tube Co., Ltd |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| S & N Stainless Pipeline Products Ltd |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| SpecialSteelStock - (C.S.C. S.P.A.) |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Stalatube Oy |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Steel Dynamics Limited |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Superior Tube Company |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| TITALIA SPA |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Tubacex Tubes Inoxidables |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| Wuxi Korer Stainless Steel Co., Ltd. |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
| ZM Tubes |           |                      |           |             |          |         |                 |      |         |         |        |         |        |        |        |                 |                |               |      |            |              |        |            |            |
Our stainless steel contains the highest proportion of recycled content on the market, and we keep pushing this further to conserve virgin raw materials. Increasing this recycled share is the single most effective measure we have to reduce our environmental impact.

The recycled content of Outokumpu steel is above 85%.

Using Outokumpu’s stainless steel decreases your own carbon footprint and that of your customers.
AMETEK 84 and Reading Alloys are global leaders in the production of Water and Gas Atomized stainless steel and high-alloy powders for P/M, Filtration, MIM, and Thermal Spray. Products include Hydride/Dehydride (HDH) CP Ti and Ti 6/4 powders as well as Master Alloys for titanium and superalloy melting.

AUSTENITIC STAINLESS STEEL
Standard grades include 303L, 304L, 310L and 316L. Other grades available upon request.

FERRITIC STAINLESS STEEL
Standard grades include 409, 410L, 420L 430L and 434L. Other grades available upon request.

SPECIALTY ALLOYS
Nickel based, Cobalt based, Copper based, and custom alloys.

HIGH PURITY HYDRIDE-DEHYDRIDE TITANIUM POWDERS

APPLICATIONS
• Thermal Spray/Medical Powders - Ti sponge, Cp Ti, and Ti 6Al/4V
• Ti powders for Powder Metallurgy (P/M) applications
• Ti powders for sputtering targets
• Advanced Coating Alloys Al/Cr, Al/Co, CODEP