

# Demanding applications: a new report on alloy optimization

A Finland-based industry-driven research consortium FIMECC DEMAPP, has just produced a remarkable report. Part of the joint R&D work related to "new corrosion-resistant materials and solutions". The aim was to develop cost-efficient stainless steels and new products to serve the pulp & paper, auto, energy and other industries. FIMECC's collaborative research is leading to the development of new ferritic stainless steels with better formability, new manufacturing methods for low-Ni and Ni-free stainless steels, and new welding procedures. FIMECC DEMAPP's work will profoundly influence the way stainless steels are fabricated and welded, and is already leading to the development of new alloys.

By James Chater



Brazilian pulp mill.

## FIMECC DEMAPP

In recent years fluctuations in the price of nickel and molybdenum has led to the development of lower-alloyed alternatives to austenitic grades in many applications. The challenge is to discover and develop lower-alloyed materials without compromising their properties. This issue is central to the research programme known as FIMECC DEMAPP (Finnish Metals and Engineering Competence Cluster; DEMAPP is short for "demanding applications"). FIMECC DEMAPP is a Finland-based public-private partnership programme of 26 companies and five research organizations. Active from 2009 to 2014, it has just issued its final report (1). The industry-driven research addresses challenges related to critical wear, corrosion, friction and fatigue, and proposes solutions for demanding applications in the process, energy and engineering industries.

The DEMAPP consortium worked with a number of international industrial partners, and some of the results achieved are already having an impact. For example, Outokumpu's new ferritic grade, which is being tested by potential customers; Ruukki Metals' (today SSAB Europe) light, energy-efficient solutions for transport and better performance for harsh crushing and mining applications; and Alteams' new cast aluminium alloys, which improve thermal conductivity by 50%. The research included efforts to reduce friction in cars, wind turbines, paper machines, diesel engines and other machinery, and wear in elevators and cranes.

The work undertaken by the programme fell under five projects: (1) Wear-resistant materials and solutions; (2) New corrosion resistant materials and solutions; (3) Extreme service conditions; (4) Friction

and energy; and (5) Production technologies for demanding applications. Project 2, related to corrosion, breaks down into four sub-projects: (1) New-generation ferritics with enhanced corrosion resistance; (2) Fabrication and service performance of advanced stainless steels for demanding exhaust applications; (3) Development of manganese- and nitrogen-alloyed stainless steels for alkaline environments; and (4) New methods for optimizing the performance of welds in corrosive industrial environments. We will examine these four areas in greater detail.

### 1) New-generation ferritics with enhanced corrosion resistance

This project set out to solve the technical problems in manufacturing



Laser welding of ferritic stainless tubular products. Photo courtesy of OSTP Finland Oy.

high-chromium ferritic grades so as to improve their corrosion resistance, formability and toughness. By experimenting with various manufacturing parameters it was found that problems such as brittleness and roping (unacceptable surface striations) after forming operations could be overcome, without recourse to expensive investment in new production technology.

The result was Outokumpu's 21Cr ferritic grade, 4622 (EN 1.4622). Its corrosion resistance is comparable to common austenitic grades 1.4301 (304) and 1.4307 (304L), and even superior in certain environments. Its PRE lies between 304L and 316L. Because of its high Cr content, it has better corrosion resistance than most ferritics. Apart from its resistance to chloride-induced stress corrosion cracking, the grade has better deep drawing properties than austenitic grades, good corrosion resistance after welding and good machinability. This new stainless has reached the trial production stage and is currently being tested and evaluated by several potential users across the globe. Laboratory testing has already demonstrated that the steel outperforms equivalent steels and has corrosion resistance at least on a par with the austenitic grades it is intended to replace. Potential

Table 5. Chemical composition of 1.4622.

C	Cr	Mn	Fe	Ti + Nb
0.02	21	0.4	Balance	0.4



Ferritics are a favourite material for use in kitchens. Photos courtesy of Outokumpu.

**STELLAR**

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Stellar Group Member

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Specification  
(OD) 6-830mm, (WT) 0.5-45mm

# Alloys

applications include cars, building facades, elevators, household items, kitchenware, panels and storage tanks.

## (2) Fabrication and service performance of advanced stainless steels for demanding exhaust applications

Tighter environmental regulations and clean energy requirements are the chief factors driving the development of new alloys for the car industry. Materials that are light but strong are needed to reduce fuel consumption and emissions. Traditionally, car exhaust systems were made of austenitics, but ferritics can perform just as well while bringing alloy cost savings. The project proposed advanced ferritic stainless steels as alternatives to austenitics. Their use up to now has been hindered by a lack of knowledge concerning their fabrication properties and their performance in extreme high-temperature operating conditions. The project set out to gain understanding of production techniques and fabricability, to acquire knowledge of oxidation, corrosion and fatigue at high temperatures and provide material selection and fabrication guidelines for advanced ferritics. It is hoped this knowledge will foster development of new products and grades. The

research resulted in new ferritic grades, improved welding procedures and new simulation tools. It was found that ferritics had good mechanical properties combined with high-temperature oxidation and corrosion resistance, and could in many cases be an alternative to austenitics.

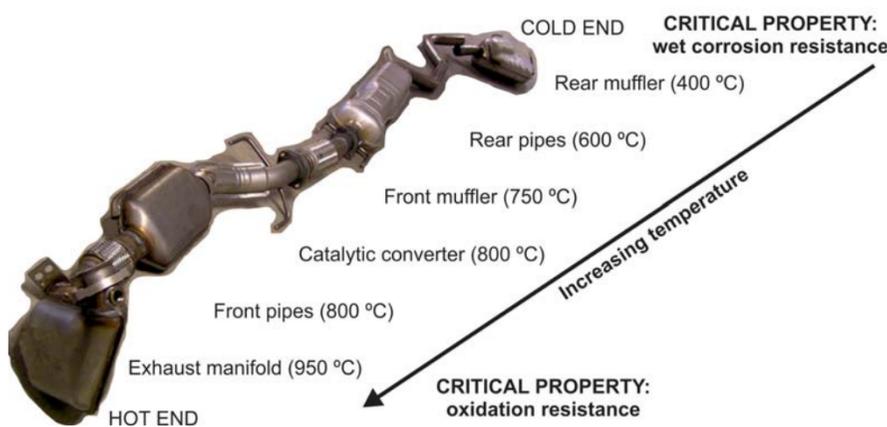
## (3) Development of manganese- and nitrogen-alloyed stainless steels for alkaline environments

This project aimed to prevent catastrophic failure of process equipment caused by stress corrosion cracking of high-strength austenitic and duplex stainless steels in alkaline sulphidic environments. This type of environment is found especially in the pulping process in pulp & paper mills.

The project had the following aims:

- (1) develop a mechanistic model for evaluation of new stainless steel grades for demanding applications in energy and pulp and paper industries;
- (2) gain knowledge to allow the production of new stainless steel grades with optimal alloying compositions (replacing Ni with Mn- and N-alloying) and pre-treatments;
- (3) provide the ability to prolong the service life of stainless steel structures by selecting initially more appropriate steel grades and manufacturing methods or by applying

### FERRITIC STAINLESS STEEL IN AUTOMOTIVE EXHAUST SYSTEMS



The diverse constraints for ferritic stainless steel materials in an automotive exhaust system. Photo courtesy of Outokumpu Stainless Oy; caption taken from Harri Ali-Löyty, "Microalloying Mediated Segregation and Interfacial Oxidation of FeCr Alloys for Solid-Oxide Fuel Cell Applications" (doctoral dissertation, Tampere University of Technology, 2013), p. 16.

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electrochemical protection; (4) contribute to structural safety and design methods in order to avoid catastrophic failures related to SCC and hydrogen embrittlement. The research produced the following findings: (1) Duplex stainless steels are suitable for structural use in high-temperature alkaline sulphidic environments; increasing nickel to 4% or more helps to avoid SCC; (2) anodic protection can prevent SCC of grade 304 in high-temperature alkaline sulphidic environments; (3) ferritic stainless steels are not suitable structural materials in high-temperature alkaline sulphidic environments as they are highly

# 2015

# Calendar

## 15-19 March 2015 CORROSION

An exhibition and conference dedicated to the study of corrosion covering topics such as pipeline, oil and gas production, coatings, and much more.  
Location: Dallas, Texas, USA  
Contact: Calae McDermott; Phone: +1 281-228-6263  
Email: calae.mcdermott@nace.org; Website: <http://events.nace.org/conferences/c2015/index.asp>

## 24-27 March 2015 NASCC The Steel Conference 2015

NASCC: The Steel Conference is the place for engineers, fabricators, detailers and erectors to learn about structural steel design and construction, to interact with their peers and to see the latest products for steel buildings and bridges. The Steel Conference offers more than 100 technical sessions and is the premier educational event for structural engineers, fabricators, erectors and detailers.  
Location: Nashville, US  
Contact: Maddie Metcalf; Phone: 312.670.5448  
Email: metcalf@aisc.org; Website: <https://www.aisc.org/content.aspx?id=37922>

## 26-28 March 2015 BORU Fair 2015, International Istanbul Tube Fair

Every two years in Istanbul. The tube trade fair for Turkey and the region for tubes, pipes, profiles, fittings, flanges and accessories.  
Location: Istanbul Expo Center, Turkey  
Contact: Organizer: İHLAS FUAR A.Ş.; Phone: +90 212 604 50 50  
Email: info@ihlasfuar.com; Website: <http://www.borufair.com>

## 16-18 April 2015 IFAT Eurasia

Messe München International is expanding its international network for the environmental technology sector. The first IFAT Eurasia takes place at the Congress International Convention & Exhibition Centre (CICEC) in Ankara. The organizers – Messe München International and its subsidiary MMI Eurasia – are expecting the premiere to attract 200 exhibitors and 7,000 visitors and take up 12,000 square meters of exhibition space.  
Location: Ankara, Turkey  
Contact: Liza Paul; Phone: +49 89 949-21502; Fax: +49 89 949 97-21502  
Email: liza.paul@messe-muenchen.de; Website: <http://www.messe-muenchen.de>

## 21-24 April 2015 Corrosion Control in the Oil and Gas Industry

Mobility Oil and Gas is accredited by the British Accreditation Council for Independent Further and Higher Education as a Short Course Provider. This four day course is intended for all engineers engaged in the oil and gas industry, in particular for those engineers involved with the inspection function and/or corrosion mitigation.  
Location: Houston, Texas, United States  
Phone: +44 203 086 7082  
Email: training@mobilityoilandgas.com; Website: <http://mobilityoilandgas.com/register-now>

## 28-30 April 2015 European Stainless Steel Conference 2015

The 8th European Stainless Steel Conference 2015 – Science and Market and the Duplex Steel Conference & Exhibition 2015 aims at gathering and sharing information on all aspects of production technology of stainless steels such as hot and cold rolling, heat treatment and so on, among delegates with academic and industrial backgrounds.  
Location: Kunsthau Graz, Austria  
Contact: Mrs. Melanie Baumgartner; Phone: +43 (0) 3842 402 2291; Fax: +43 (0) 3842 402 2202  
Email: stainlesssteel2015@asmnet.at; Website: <http://www.stainlesssteel2015.org/about-conference>

## 4-7 May 2015 Offshore Technology Conference 2015

During four days in the OTC exhibition hall, your company can showcase its products and services to the world's leading experts and decision-makers in the offshore energy industry. OTC brings together more than 100,000 industry leaders and buyers from more than 130 countries who want to explore how technology, best practices, emerging trends, and proven methods are making waves in the evolving landscape of the industry.  
Location: Houston, Texas, USA  
Phone: +1.972.952.9494; Fax: +1.713.779.4216  
Email: meetings@otcnet.org; Website: <http://2015.otcnet.org>

## 19-20 May 2015 Myanmar Oil and Gas

TOTAL, Shell, Statoil, Chevron, Eni, ConocoPhillips are just some of the world's leading companies who have expanded their business into the largely unexplored Myanmar oil and gas sector. Join these companies and gain your local market share by participating at the 2nd Myanmar Oil & Gas Exhibition and Conference taking place on 18 - 21 May 2015 at the Sule Shangri-La Hotel (formerly Traders Hotel) in Yangon, Myanmar. This event is officially supported by the Ministry of Energy of the Republic of the Union of Myanmar.  
Location: Yangon, Myanmar  
Contact: Abi Singh; Phone: +44 754 066 1329  
Email: abi.singh@ite-events.com; Website: <http://www.myanmar-oilgas.com>

## 20-22 May 2015 Tubtaly

Tubtaly 2015 will take place from May 20 to 22 next 2015 at the fairgrounds in Piacenza Expo - Italy. The event will show the best of tubes, valves, rods, pipes, profiles and technologies for their production and processing.  
Location: Piacenza, Italy;  
Contact: PIACENZA EXPO; Phone: 0523.602711; Fax: 0523.602702  
Email: commerciale@piacenzaexpo.it; Website: <http://www.tubtaly.it>

## 27-29 May 2015 Indowater 2015

11th International Water, Wastewater & Recycling Technology Expo & Forum in Jakarta. The event takes place every year alternately in Jakarta and Surabaya. The last INDOWATER Jakarta in 2013 attracted 503 exhibitors from 30 countries and 7150 trade visitors.  
Location: Jakarta  
Contact: MEREBO Messe Marketing; Phone: +49-40-3999905-0; Fax: +49-40-3999905-25  
Email: contact@merebo.com; Website: <http://www.indowater.merebo.com>

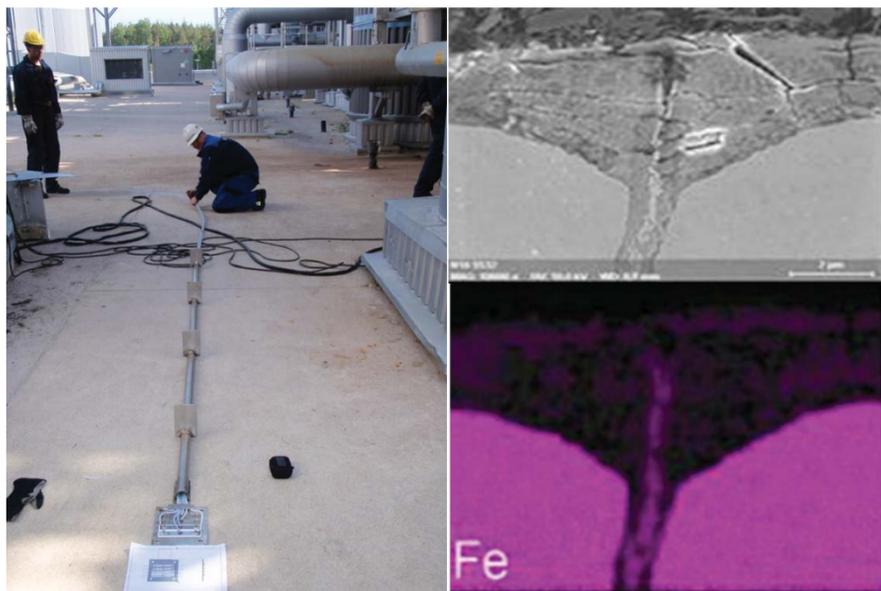
## 2-4 June 2015 OGA 2015

The 15th Asian Oil, Gas & Petrochemical Engineering Exhibition.  
Location: Kuala Lumpur, Malaysia  
Contact: Ms Norisma Ismail; Phone: + 603 4041 0311; Fax: + 603 4043 7241  
Email: norisma@mesallworld.com; Website: <http://www.oilandgas-asia.com/home/index.php>

## 28 June-2 July 2015 2015 ASME Power & Energy Conference

In 2015, four of ASME's major conferences come together to create an event of major impact for the Power and Energy sectors: ASME Power & Energy 2015. Fossil and nuclear power generation, solar, wind, fuel cell applications and much more will be discussed in each of the four concurrent conferences within this larger event.  
Location: San Diego, US  
Contact: Greg Valero; Phone: 1.212.591.8356  
Email: valerog@asme.org; Website: <https://www.asme.org/events/power-energy>

# Alloys



Field corrosion measurements at a pulp mill conducted by Savcor Forest Ltd (left). Scanning electron microscope picture of a stress corrosion crack in AISI 304 austenitic stainless steel after two-week exposure to a simulated hot black liquor environment (right), showing a flux of iron emanating from the middle of the crack (selective dissolution of iron).

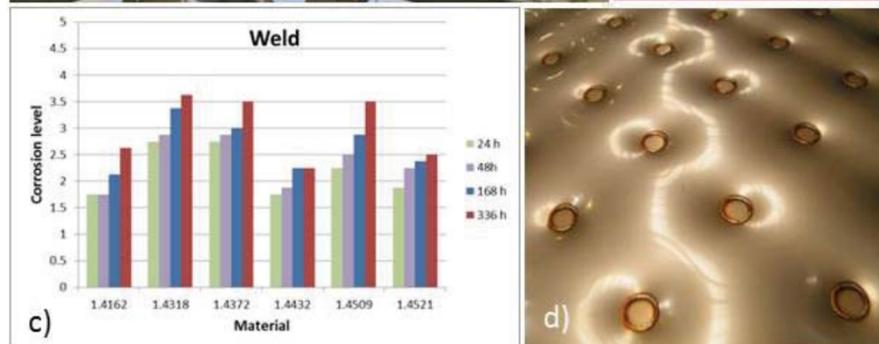
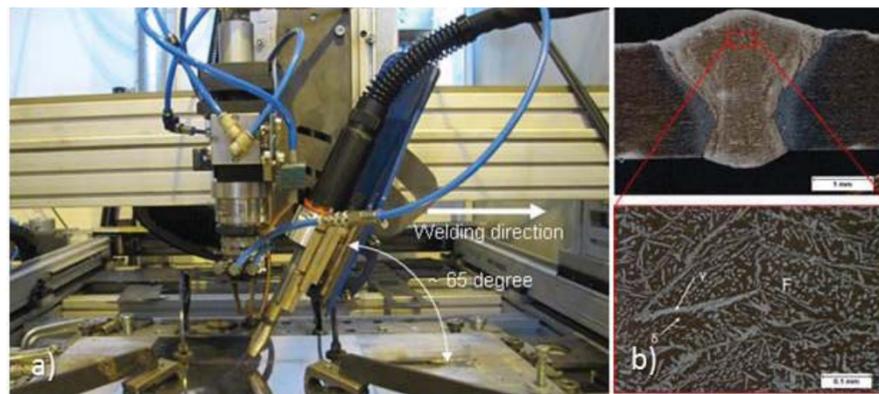
susceptible to SCC; (4) Mo alloying has an adverse effect and Cr alloying a positive effect on the corrosion resistance of stainless steels in Na<sub>2</sub>S-containing caustic environments.

#### 4) New methods for optimizing the performance of welds in corrosive industrial environments.

Fluctuating nickel prices have led to a demand for low-nickel alloyed stainless steels, and their use is expected to grow in the pulp & paper and process industries. But substitution of existing materials requires better understanding of joining and joint performance in the service environment. Novel stainless steels need to be researched to improve knowledge of their corrosion characteristics and behaviour, and to understand how weld metallurgy and corrosion resistance of welded joints interact. Better

welding procedures, with the emphasis on advanced, high-productivity technologies, need to be established. During trials, laser-arc hybrid welding was used. This is a fusion-welding process where both a laser beam and welding arc – typically MIG/MAG or TIG – are focused simultaneously in the same weld pool. Trials were conducted on three base materials, two ferritic (1.4509 and 1.4622) and one duplex (1.4162) stainless steel, using four different types of filler metals and three joint configurations. Various adjustments were found to be possible with regard to weld metallurgy, dilution rates and weld chemistry.

**Next Wave – FIMECC BSA & Hybrids**  
FIMECC is now running two follow-on programmes exploiting the ecosystem and the active co-operation model



[X-Weld fig 1, X-Weld fig 2, X-Weld fig 4 correspond to a, b and d above]  
a) Laser-arc hybrid welding arrangement allowing: b) micro-structural tailoring for e.g., c) optimized corrosion resistance of d) components in true service conditions.

proven by DEMAPP. FIMECC BSA (Breakthrough Steels and Applications) develops use of stainless steels in various application areas, e.g. in the process and energy industries (2). The programme also includes basic R&D on characteristics of the new 21% Cr stainless steels 4622 and 4420, and development of completely new generic stainless steel alloys with optimized property combinations. FIMECC Hybrids (Hybrid Materials), in turn, creates innovative solutions through functional coatings and combinations of engineering materials (3). This industry-driven R&D co-operation (budget EUR 80 million for 2014-18) brings together

63 companies and nine research organizations, including the FIMECC Breakthrough Materials Doctoral School, with 34 positions.

#### References

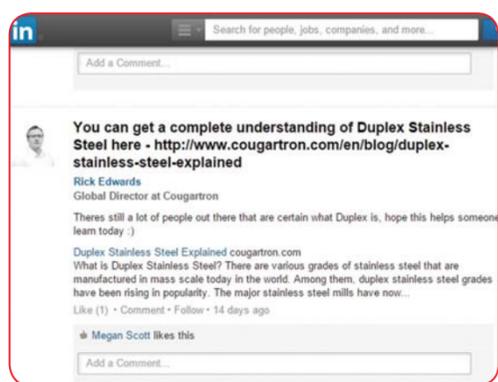
- (1) "Breakthrough Materials for Demanding Applications – from Science to Solutions", is available at: <http://hightech.fimecc.com/results/final-report-demapp-breakthrough-materials-for-demanding-applications-from-science-to-solutions>. An English summary can be found at: [www.fimecc.com/news/all-first-fimecc-final-reports-now-published](http://www.fimecc.com/news/all-first-fimecc-final-reports-now-published).
- (2) See [www.fimecc.com/programs/bsa](http://www.fimecc.com/programs/bsa).
- (3) See [www.fimecc.com/programs/hybrid](http://www.fimecc.com/programs/hybrid).

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#### Everything you need to know about electropolishing



One of our LinkedIn Members has posted a link to a very nice article about the electropolishing of stainless steels. It is written by a supplier, but nevertheless does provide a good step-up for someone looking for the basics. For example, there are sections on the working principles, the setup, possible post treatment, etc. To find this source, just scan back through the "Discussions" in our LinkedIn Group, which can be found at [www.linkedin.com](http://www.linkedin.com) by entering "stainless steel world group" in the search field.



#### Introducing Duplex World



Have you seen our latest website dedicated to all things duplex yet? It was launched after listening to the many ideas and suggestions from our community about what they wanted to see, hear and read about these versatile alloys. So for example the website features blogs written by duplex professionals, a discussion page, a section where parties can meet to buy and sell, and in addition to that there's a regular news feed, a huge library of technical resources, videos about duplex makers and users, etc. Why not check out our dedicated duplex resource at: [www.duplex-world.com](http://www.duplex-world.com)?



#### Schmidt + Clemens promotes new nickel alloy



During a recent event organised by sister publication Pump Engineer we ran into an old friend, Mr Christian Lenz, from Schmidt + Clemens. At the show, he was actively promoting a new nickel alloy which, he said, could be a very interesting and economical alternative to existing nickel alloys in, for instance, pumps for chemical industry applications. To see Mr Lenz's video interview on this new grade, please go to: [www.stainless-steel-world.net/G45Mo](http://www.stainless-steel-world.net/G45Mo).



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