CORROSION & Materials

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In this issue:

FEATURE: CATHODIC PROTECTION

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

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CONTENTS

BOARD CHAIR'S REPORT

It is a privilege to offer some reflections on this comeback issue of Corrosion & Materials. During the recent AMPP conference, I have crystallised some thoughts with peers which I would like to share with you.

You may be aware of the launch of the Australian Chapter as AMPP's 100th. Rest assured that the ACA and AMPP are committed to maintaining a non-competitive, symbiotic relationship. Our collaboration is founded on our Strategic Alliance and will continue to be. I extend my congratulations and best wishes to Justin Rigby and Andrew Russell, who have been nominated as President and Vice- President of the Chapter, respectively. Both Justin and 'AJ' have been steadfast supporters of the ACA for a considerable time and will continue to contribute to and bolster our initiatives.

As a newcomer to the AMPP conference (although a longstanding AMPP member), it was quite an experience representing the ACA Membership in New Orleans. The event hosted over 6000 attendees and featured 30 concurrent streams of papers and working groups. Some notable highlights include:

- Engaging in discussions with the AMPP CEO, COO, and Board Chairs regarding our strategic alliance, respective strategic directions, training, and advocacy.
- Meeting with advocacy leaders and expressing enthusiasm for the grassroots advocacy with a potential tool kit provided by the office but led by the members.
- Participating in the Train the Trainer session with 120 lecturers, focusing on increasing student engagement.
- Engaging with international sister organisations in a workshop-style format.
- Attending the Emerge function, during which $120,000 in grants/awards were distributed to students, similar to the ACA Foundation's initiatives.
- Attending the Awards Dinner, where prestigious leaders were honoured and recognised.

Having been an ACA Member for over 20 years, the past few months have been particularly different since I undertook the challenge of serving as Board Chair. During this time, we have achieved several significant goals, including:

- Modernising and approving updated bylaws to clarify discrepancies and incorporate key elements integral to the association.
- Approving the 2024 budget, which strikes a good balance between improvements, member services, and achieving a break-even point.
- Implementing a slight increase in member fees to align with other organisations, resulting in more benefits for our members.
- Approving the eagerly anticipated return of the Corrosion & Materials journazine in a digital format.
- Reviewing and confirming the strategic plan with minor amendments.
- Conducting a professional development session with Associations Australia on topics such as board governance, effective decision-making, and company structures.

We are off to a great start to the year, and I look forward to seeing our members engage at Branch events and ACA activities. I also ask you to invite a colleague, supplier, or client to an event to spread the word.

If you want to talk to me, you can contact me directly on kingsley.brown@corrosion.com.au.

Kingsley Brown

ACA Board Chair

CONTENTS

Reports

Conference

Feature: CATHODIC PROTECTION

Feature: CATHODIC PROTECTION

Member Profile

CONTENTS

State Reports

Branch Profile

Technical Group Chair Profile

Young Corrosion Group Profile

News

Case Studies

Member Benefits

Dear Members of the ACA,

I am thrilled to be part of the relaunch of our specialised Corrosion & Materials journal and share a message with our membership. This relaunch represents not just a renewal of our commitment to providing advanced insights and developments in corrosion management but also signifies our dedication to cultivating a unique space for learning, innovation, and community engagement.

I am very pleased to welcome the new Council members for the 2024 term. Our initial meeting this March affirmed our commitment to being a cornerstone for the ACA, providing robust support across all levels from the Board, Branches and Technical Groups to our Members.

As the Council President of the Australasian Corrosion Association (ACA), I see the Council's role as a pivotal connector within our community. The Council is especially committed to enhancing education, training, and professional development efforts. We see great value in ACA's programmes that elevate the expertise of our practitioners and to draw in the next generation of professionals.

Additionally, we're dedicated to supporting the ACA's advocacy initiatives. We want to amplify our collective voice in advocating for more of our certified practitioners being included into standards.

I am also happy to report on our recent activities and initiatives. The AMPP conference was an enriching experience, offering valuable discussions on corrosion prevention and our Association's development. I participated in the Sisters Society meeting, that allowed us to engage in rich discussions with global corrosion associations, underscoring our shared dedication to sustainability and advanced mitigation techniques.

I look forward to representing the ACA in more events and contributing to the future of our organisation.

Warm regards,

Isaac Isakovich Castillo

ACA President.

Welcome to the first issue of Corrosion & Materials for 2024. Our highly anticipated journal has been in our plans for a while and we are pleased to offer it as part of our new Membership package, launched in February.

Future member benefits in development include our Member Portal. By the second half of 2024, our members will be able to access corrosion papers, booking for events and training via the portal and update membership details as required.

We have had a busy first quarter of the year. We worked to refine and finalise our strategy and business plans. In February, I attended the AMPP Conference with our Board Chair, Kingsley Brown, and then at the end of March I visited our Branches in Newcastle and Sydney.

Our Branch Executives and our Technical Group Chairs do a great job, and we are so thankful for their time, commitment, and leadership.

Our main focus this year is 'asset owners' and 'advocacy'.

Our plan for Asset Owners is:

- Build a database of as many asset owners to rebuild our engagement and relevance.
- Work with our Branches to build a network of people that interact with asset owners to build our engagement through those trusted contacts.

Our current advocacy activities include:

- Green Star Construction Standards – these standards are increasingly being specified for new buildings and infrastructure. The ACA is advocating for practical approaches that consider the challenges of our paint manufacturers, steel fabricators and our builders to meet these standards without losing the integrity of coating and other corrosion applications.
- Quality of our workforce – lobbying Ministers around Australia (and New Zealand) to recognise Industrial Painters as a trade and extend the TAFE Certificate III training opportunities, especially for young people looking to enter a trade from high school.
- NAVSEA standards for Sustainment in Australia – we are exploring the opportunity for some US Navy NAVSEA standards to lift the requirement of our craftworkers in Australia.

If you have suggestions on areas that you would like to see the ACA, get involved to advocate for issues, please let me know at maree.tetlow@corrosion.com.au

Maree Tetlow

ACA CEO

CORROSION & PREVENTION CAIRNS 2024

Cairns Convention Centre | 10 - 14 November 2024

Navigating Corrosion Challenges in Marine and Coastal Environments

Corrosion & Prevention 2024 will feature a full program of peer-reviewed papers and case studies, technical forums, research symposium, networking and more. The conference will be a platform for industry field practitioners who combat corrosion on a daily basis and researchers working in corrosion-related fields to share and exchange ideas.

Corrosion & Prevention is Australasia's premier conference for those involved in all areas of corrosion mitigation. Over the years Corrosion & Prevention has grown to include a diverse array of technical streams, exhibitors from all over the world and unique social functions.

The conference and affiliated events are the perfect opportunity to grow and build brand awareness, make important industry connections and foster education and growth within different industry sectors.

TECHNICAL STREAMS

Diverse technical streams will showcase the latest developments in corrosion prevention, ranging from scientific research to hands-on applications.

Topics will include concrete corrosion and repair, steel corrosion, water infrastructure, cathodic protection of pipelines, asset management, high-temperature corrosion, non-ferrous metal corrosion and microbiologically influenced corrosion.

In addition to the technical program, the exhibition will be an integral part of the activities, providing an opportunity for delegates to experience the latest products and services.

As always, Corrosion & Prevention 2024 will provide the premier venue for networking opportunities. Building on their well-established reputation, the social functions including the welcome function and exhibition, the ACA awards dinner and the farewell function will not disappoint.

REGISTRATION OPENS JUNE 2024

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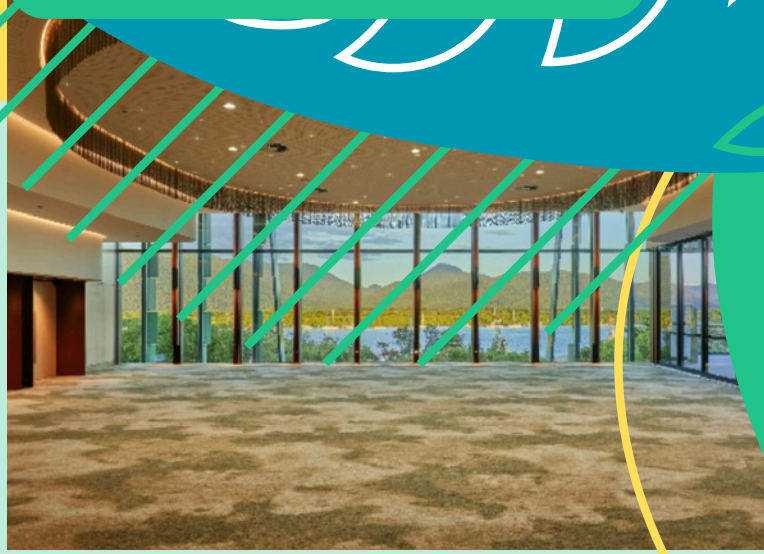


THE DESTINATION: CAIRNS

Cairns is a vibrant city that promises an unforgettable experience for conference attendees. Renowned for its warm, tropical climate and laid-back atmosphere, Cairns offers a unique blend of natural wonders and modern amenities.

Explore the majestic Great Barrier Reef, the world's largest coral reef system, through snorkeling or diving tours that reveal vibrant marine life in crystal-clear waters. The ancient Daintree Rainforest, a UNESCO World Heritage site, offers a glimpse into prehistoric flora and fauna on guided walks or zip-line tours for the more adventurous.

For a taste of local culture, the Cairns Esplanade, with its lagoon, bustling markets, and lively eateries, provides a relaxed atmosphere to unwind after conference sessions. Don't miss the chance to take a scenic railway journey to the picturesque village of Kuranda, known for its vibrant arts scene and indigenous heritage.

Cairns is not just a conference destination; it's an invitation to experience the heart of Australia's natural beauty.

Harnessing Cathodic Protection Techniques to Preserve Australia's Coastal Assets

Cathodic protection is a technique used to control the corrosion of a metal surface. The practice is widely used in storage tanks, offshore platforms and pipelines to minimise corrosive damage and extend the lifespan of these products.

Australia is a nation built by the water. In fact, 87 per cent of the population lives within 50km of the coastline, according to the Australian Bureau of Statistics. But these residential and commercial buildings; critical infrastructure for the oil and gas sectors; and much of the marine industry are prone to the impacts of corrosion.

Research based on AMPP research (ex NACE) indicates that corrosion can cost the community between 3.5% and 5.2% of Global Gross Domestic Product. If we apply this to the Australian and New Zealand environment, that equates to $100 Billion per year. Therefore, it is an issue that must be addressed, and cathodic protection is an important part of the solution to protect our assets.

There are two types of cathodic protection techniques: galvanic anode cathodic protection (GACP); and impressed current cathodic protection (ICCP).

Firstly, GACP connects a more reactive metal, better known as an anode, to the metal that needs protection. This metal, a cathode, is connected with a metallic conductor. It creates a galvanic cell where the sacrificial anode corrodes instead of the protected metal. While a variety of materials can be used in this process, zinc and magnesium are the most typical sacrificial anodes. Meanwhile, ICCP requires an external power source, known as a rectifier, to apply a direct current to the metal structure.

ICCP is often employed when galvanic protection does not provide sufficient control over corrosion, or for much larger structures where additional control is needed. A suite of factors will contribute to whether a company uses GACP or ICCP techniques. For example, GACP techniques are typically used in offshore activities, like underwater equipment or pipelines. In comparison, ICCP is better used for onshore and maintenance activities, like working on the hull of a ship. The practice of cathodic protection is backed by legislation for the safe operation of oil and gas pipelines.

How Does Cathodic Protection Work?

Vulnerable metals, coming into contact with a corrosive environment, rely on an external anode to avoid corrosion. Once this is activated, the metal is manipulated to avoid the electrochemical response that causes corrosion. This means equipment or structures buy more time because the corrosion process is significantly slowed down. It also has vast environmental ramifications because it minimises the need for ongoing maintenance and replacement.

However, a cathodic protection system should not be a cookie-cutter approach. The surrounding environment and conditions play a crucial role in the selection of a cathodic protection system. As such, practitioners are encouraged to use the design stage as the prime opportunity to understand their working environment and prepare to enhance the structure's longevity. The protective current should be applied in a uniform manner across the structure. After a complex electrochemical reaction occurs to the metal surface, end-users will feel confident their product or equipment is safe from future damage.

Specialists in cathodic protection will typically hold a relevant tertiary degree in an area like science or engineering. However, many practitioners may have completed an apprenticeship before undertaking additional training in the field. Cathodic protection is underpinned by AS/NZS 2832—Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings. This Australian Standard stipulates the requirements for fixed immersed structures; steel in concrete; pipes and cables; and buried structures.

Australian Companies at The Forefront

Given Australia's geography and the proximity of critical infrastructure to the coast, local companies are pioneers in cathodic protection and anti-corrosion techniques. Eptec Group is one Australian trailblazer making strides in the sphere of anti-corrosion coatings.

The company, a proud Australasian Corrosion Association member, works with a suite of defence and infrastructure clients to prevent corrosion and ongoing environmental damage.

Eptec Group also offers in-depth expertise to deliver cathodic protection systems and benefits in many sectors. Corrosion Control Engineering (CCE) is a part of the EPTEC Group, and Australasia's largest and most experienced corrosion engineering company specializing in all aspects of Cathodic Protection and related fields. CCE specializes in the use of cathodic protection to preserve buried or immersed metallic structures from natural and chemical corrosion processes.

EPTEC Group also specialise in the martime sector. For example, the Australian Government has invested into a new fleet of submarines, which will rely on nuclear-propulsion technology. The arrangement is a

key feature of the AUKUS security alliance, between Australia, the UK, and US. Under the deal, Australia will acquire nuclear-powered submarines relying on technology and expertise from these foreign partners.

They will add to the existing fleet of Collins-class submarines, which have been crucial to Australia's defence since 1996. Because of their age and exposure to the marine environment, the Collins-class submarines are prone to corrosion.

However, the Eptec Group and partner ASC, have developed a $66 million blast and paint contract to extend the life of these vessels. The project will support more than 100 jobs on full cycle dockings in Adelaide.

Geoff Knox is the Group Chief Executive Officer of Eptec, who said more than 100 workers would be enlisted during each full cycle docking to deliver the blast and paint services.

"Eptec's high-performing, multi-skilled workforce is committed to supporting Australia's defence capability and the maintenance of critical assets like the Collins Class."

The six-year agreement means Eptec will provide blast services to clean submarine components and systems. This minimises the impacts of ongoing corrosion damage and maximises their operation.

The painting includes anti-corrosion protection for the submarine's hulls and internal structures. There will also be a complete refresh of living areas including galleys, walls and ceilings to improve amenities for Australian crews.

ASC Chief Executive Officer Stuart Whiley said strong relationships with local businesses are important for the Collins program.

"The significant national security investments which are being made to grow Australia's submarine capability are also creating hundreds of jobs, both at ASC and with suppliers."

Eptec is a strong service provider who can be trusted to deliver ease of access to services, and support Australia's industrial resilience.

The company's reliability and success are seen in the return business from a broad range of international clients including the US Navy; Royal New Zealand Navy; and private operators like Carnival Cruise Lines.

Australasian Corrosion Association members have access to the next level of knowledge sharing, networking, training, and development opportunities. The membership base is a launchpad to events that means companies can connect and work together towards the shared challenges in the sector.

Savcor Products Australia are among the members who protect oil and gas pipelines; wastewater facilities; concrete infrastructure; and storage tanks. The company offers corrosion and cathodic protection related products such as anodes, coatings, corrosion inhibitors, monitoring equipment, testing and measuring instruments.

Similarly, Freyssinet is a Melbourne-based remediation and civil engineering firm, who undertake cathodic protection services. Freyssinet is involved with condition assessments, design, supply and installation of the systems to control the ongoing movement of corrosion. The company employs ICCP, hybrid and galvanic systems.

How One of Australia's Key Ports Tackled Corrosion

NSW Ports recently commissioned Infracorr to design a cathodic protection system at BLB1, located at Port Botany, which contains hazardous gas pipelines.

Port Botany and Sydney Harbour are among several ports at risk of chloride-induced corrosion.

Teams repaired a series of defective concrete structures, which were suffering from the effects of corrosion and concrete damage.

The presence of hazardous materials in the environment also meant the system required the design for tight control of the currents and voltages used across the site.

Any stray sparks caused by excess voltages and currents could become an ignition source for a major fire or explosion, and many of the structures present were constructed using prestressed concrete.

As such, all electrical currents applied were carefully controlled to avoid any structural damage caused by over protection.

Teams navigated the off-the-shelf cathodic protection system available, which had certification for use in zone one classified hazardous areas.

It meant that a bespoke system had to be designed that met the cathodic protection objectives, including dealing with the challenge of prestressed concrete.

Practitioners also sought to meet the necessary requirements under AS/NZS 60079 regulations.

The system, designed by Infracorr, was a hybrid that combined the properties of both passive galvanic and impressed current cathodic protection.

Since then, it relies on remote monitoring technology to provide teams with ongoing reassurance that it is operating as intended.

The system performance and corrosion levels are continuously monitored using 24 remote monitoring units situated throughout the site.

Omniflex was tasked with advising on the remote monitoring aspects of the design.

Hydrogen Induced Stress Cracking of Swaged Super Duplex Stainless Steel UNS S32760

Curtin University's Corrosion Centre has been at the forefront of state-of-the-art research and science for over 30 years. Scientists and engineers deliver corrosion related science tailored towards a range of industries, including defence chemical processing; mining; and oil and gas.

For example, researchers study localised corrosion and environmentally assisted cracking (EAC), microbiologically influenced corrosion (MIC), and corrosion under insulation (CUI).

The Centre also offers a consultancy service in which subject matter experts work with specialist teams.

Industry partnerships are also critical for the Centre's work. Together, this end-user driven research and development accelerates Australia's resilience towards corrosion damage.

For example, Curtin University and Chevron Australia are in development of a $4 million Extreme Service Flow Loop facility.

The new venture, based at Technology Park near the University's Bentley campus, will revolutionise how offshore facilities manage corrosion.

Project Chief Investigator Dr Ammar Al Helal said natural gas is vital to transition to clean energy.

"The flow loop will be made from Hastelloy, a high nickel alloy able to withstand extreme corrosive conditions."

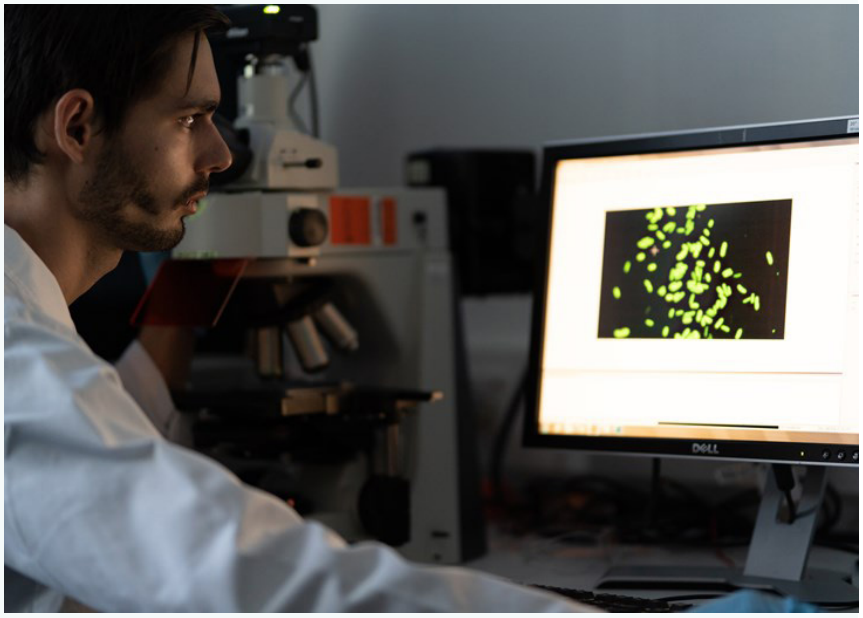
"It will simulate various corrosive conditions found inside pipelines and other high-flow environments in the industry," he said.

The Curtin and Chevron joint project will not only offer an Australian-based alternative to overseas testing but will also be the only flow loop in the world capable of mirroring corrosive conditions in the presence of mercury vapour.

"This will allow operators to better measure and predict the effects of corrosion on a given project, which will not only reduce costs but also reduce the risk of damage to infrastructure and the environment," Dr Al Helal said.

In other facilities, this can result in escalated costs, lengthy time delays and limited control over testing.

The flow loop will be available to other companies for their own research and development needs after the initial completion of the Chevron research program.



Student Research Powering the Next Generation

Students are critical to Curtin University's Corrosion Centre.

Researchers work with the next generation of practitioners to offer training in the use of pressure vessels and flow equipment important. This is vital for work in a variety of corrosive environments, particularly in the petroleum industry.

The Centre also invites PhD students to work within the team. The PhD program means students get real-world experience to work with partners and develop innovative solutions to anti-corrosion measures.

Previous student projects have investigated the scope for polymers and composites to replace carbon and low alloy steels in various oil and gas environments.

Meanwhile, another study sought to better understand the procedures associated with affected microstructures, and establish an acceptance criteria.

All students have the opportunity to work at the Centre's EXTREME Laboratory. This one-of-a-kind facility allows students to test a variety of high-temperature materials, and better understand microbiologically influenced corrosion.

All images courtesy of Curtain University.

Artificial Intelligence Tackling Jetty and Port Corrosion

Artificial intelligence has improved the maintenance of marine structures susceptible to corrosion.

The Curtin Corrosion Centre, supported by the SmartCrete CRC, recently deployed a monitoring tool to find better ways to repair ageing jetties and ports impacted by corrosion.

Lead researcher Dr Mobin Salasi said marine structures commonly corrode because of their exposure to harsh conditions.

"Each year, 30 billion tonnes of concrete are used for construction, and some of the structures subject to harsh conditions, such as the ocean, which can have a significant impact on their strength and capability to last."

"The annual cost of corrosion-related infrastructure in Australia is currently estimated to be $100 billion and can lead to loss of functionality, high maintenance costs, and in rare extreme situations, catastrophic failures causing injuries," Dr Salasi said.

The salt water 'splash zone'—where the movement of water and high levels of oxygen and chlorides—induce the perfect corrosive environment.

Curtin researchers addressed the problem from two fronts: monitoring and repair.

"Concrete corrosion is a complex multifactorial phenomenon, so the team will develop a new AI-based decision-making tool that will be fed data and images on the marine structures and then the algorithm will produce reports of high-risk areas for the Port authorities, so the maintenance strategies can be scheduled,' Dr Salasi said.

Marine structures play a crucial role in shipping and transport. As such, researchers are working with industry bodies to ensure the long-term impacts are minimised.

Professor Mariano Iannuzzi, who is the Director of the Curtin Corrosion Centre, said this is an exciting opportunity for researchers from multiple organisations to come together.

"Our partners will work together on this innovative and intelligent tool, which will lead to cost savings in the long term, while also helping to reduce the environmental impact caused by these corroded structures."

The collaborative project also includes researchers from Curtin's School of Civil and Mechanical Engineering, Macquarie University, and the Qatar Environment and Energy Institute at Hamad bin Khalifa University.

The 'Magic' Behind Cathodic Protection

Duratec Australia are experts in the mitigation of corrosion in concrete and steel structures. The company offers cathodic protection techniques to extend the lifespan and resilience of many steel-reinforced concrete structures. These include bridges, tunnels, buildings, and wharves and jetties.

Duratec employs three types of cathodic protection systems:

1. Sacrificial anode CP systems: in which a metal anode is attached to surfaces that are most vulnerable to corrosive environments.
2. Impressed current CP systems in which inert anodes with an external power source are used for assets with a demand for high currents.
3. Hybrid anode CP systems: this is a combination of the other two systems, which uses an external power source to provide initial polarisation to the asset.

Together, the company uses a holistic approach to cathodic protection, including a thorough design and installation service, monitoring and maintenance.

Cathodic protection is used in many commercial and residential buildings. In fact, a standard hot water system in a residential property may contain anodes, which are designed for increased protection and longevity.

Without these anodes, the hot water tank would deteriorate over time through a perforation from the inside.

Duratec has worked with clients across a variety of sectors to deliver cathodic protection services.

For example, Duratec worked on the Eden Chip Mill wharf in Twofold Bay, NSW.

The company deployed a sacrificial anode cathodic protection system, which was designed to protect a range of steel piles.

In all, 44 aluminium anodes were installed across 11 structural bents.

Once the project was completed, Duratec conducted a post-installation analysis. This demonstrated the high performance of the bents, which meant they were receiving adequate cathodic protection from the anodes.

The Duratec Difference

Duratec are a solutions-driven company who are focussed on all aspects of engineering. The company places a large emphasis on people, systems and technology, and sustainability.

Some of the services include:

- asset protection and management
- durability engineering
- building refurbishment
- infrastructure protection and upgrades
- specialist access systems.

The company employs a 360º management structure—engineering, construction, remediation—to ensure all customers receive tailored solutions to match their needs. Duratec offers a selection of high protective coating systems for a variety of applications. The services include abrasive blasting and painting; cathodic protection; joint remediation; waterproofing; and acid protection.

Duratec is a proud Australasian Corrosion Association member. This opens the door for networking events, research and development programs, and advocacy.

Members are able to leverage their expertise in a shared knowledge environment.

Wharf Remediation and Cathodic Protection

Victoria Harbour lies on the doorstep of Melbourne's CBD. The area—popular with visitors and often busy with football fans—boasts one of Australia's largest collection of sustainable residential buildings.

However, the area is also surrounded by water on three sides, which makes these buildings and the nearby environment susceptible to corrosion. As such, Lend Lease engaged Duratec to perform remediation works along the wharf.

The Duratec team oversaw the installation of a hybrid cathodic protection system, alongside structural enhancements and pile splicing. Together, this was designed to provide long-term protection to the concrete deck soffit and transverse beams.

The team also carried out concrete repair works and steel reinforcement. Finally, a layer of silane coating was applied to the lower parts of the untreated concrete beams. The project required extensive planning to overcome several challenges associated with the local environment.

The project team also had to navigate the Council imposed curfew, which comes into effect overnight because of the nearby residential area. Despite this, the project team delivered the transformation on time and met budgetary requirements.

Sea Baths Hybrid Cathodic Protection

Duratec was commissioned by Knight Frank to remediate corroded concrete at the St Kilda Sea Baths.

The baths, located along Melbourne's popular St Kilda Beach, have been in operation since 1860. The nearby area is often busy with a suite of restaurants, cyclists and pedestrian areas.

The sea baths, and surrounding areas, have experienced a range of extreme weather conditions and changes to the environment during this time.

As such, Duratec repaired the damage at the sea bath's pool plant room by installing a hybrid cathodic protection system.

This involved a suite of works, including:

- the breakout of all divided concrete on the plant room main wall
- a thorough inspection and augmentation of steel reinforcements
- a reinstatement of a breakout using a concrete repair mortar
- the drilling of 550 holes to install hundreds of discrete anodes
- the termination of cables into a junction box
- backfilling anode holes and cable chases with a repair mortar.

One of the highlights of this project was the inspection and monitoring of anodes by measuring the current to ensure they switch to galvanic mode.

Duratec completed this with ease because of their strong collaborative effort and focus during the design process.

Duratec was able to safely navigate the tight shutdown and work in close proximity to other tradespeople.

Jotun Places Corrosion Protection on The World Stage

For almost a century, Jotun has grown into one of the most prominent paints and coatings manufacturers. Over 10,000 employees operate across 100 countries delivering state-of-the-art solutions covering shipping; energy; architecture and design; and energy.

The company was founded by business entrepreneur Odd Gleditsch Snr. in Sandefjord, Norway.

He sailed the ice cold waters observing materials and how they respond to the harsh conditions. In fact, he saw many ships and steel structures corroding away in his travels.

The Second World War was a challenging time for Jotun, which was struggling from a lack of raw materials and production. However, the company slowly bounced back and began its international expansion soon after. This growth has been sustained, alongside new expertise and technology, which Odd Gleditsch Snr. would fully embrace.

Today, the company is a trailblazer in corrosion detection and solutions. Corrosion can be a difficult process to defeat. After all, the degradation of iron into iron oxide is a natural process. However, some materials and structures are more susceptible to this kind of damage than others. Ship structures and machinery are often degraded because of their ongoing exposure to seawater and corrosive cargoes.

Estimates from the Australasian Corrosion Association show corrosion costs the local economy $100 billion per annum. However, there are ways of tackling this problem and minimising costs.

Anders Skilbred is Research and Development Senior Chemist Testing Department at Jotun Performance Coatings, who said testing is essential to understanding the dangers of corrosion.

"Improving the protective and anti-corrosion effect of coatings is an ongoing area of research for coatings manufacturers but bringing new products to market can only be done after extensive testing."

"Being able to estimate and ensure the lifetime of a protective coating is of the utmost importance, often being the key aspect when designing or choosing appropriate coating systems for application," he said.

There are no limits to Jotun's research and development objectives. For example, Jotun operates a test station with coated panels in Antarctica. The facility is located close to the Norwegian Research Station, which has benefited from Jotun coatings since 1994.

This means Jotun has operations across every continent, which it uses to directly monitor the vast environmental conditions. The corrosion monitoring process is highly digitalised. In fact, Jotun has connected a series of test panels with a highly advanced sensor. It means scientists can view real time data at any given time from a remote location.

Jotun is an Australasian Corrosion Association Platinum Member. This opens a world of opportunity to connect and discuss the latest developments from the sector. The Australasian Corrosion Association is only as strong as our membership base. As such, we are proud to provide a platform for training opportunities and professional development events. Together, this enhances your practices and ambitions in an informative manner, alongside likeminded organisations.

Offshore Wind Substructure Surface Maintenance

Wind turbines are among the structures prone to corrosion, especially those located in offshore farms. The combination of harsh atmospheric conditions and the unpredictable marine environment, means practitioners need to take matters into their own hands to limit corrosion.

Jotun has pioneered a glass flake polyester solution, Baltoflake, to ensure decades of protection for offshore wind substructures. This development also reduces lifecycle costs by up to 50 per cent.

Ismail Tan is Jotun's Global Category Manager—New Construction Primers, who said the coating has been tested on a North Sea oil platform, which was installed in 1972.

"Although glass flake coatings have been used in the energy industry for over 40 years, there has traditionally been very little research into the material's long-term benefits."

Glass flake coatings have a proven ability to resist the ongoing economic and safety impacts of corrosion. They are able to counter a wide range of acids, alkalis, solvents and salt solutions, while displaying excellent thermal stability.

"Baltoflake removes the requirement for offshore wind developers to undertake expensive repairs or replacement due to corrosion. By reducing overall maintenance costs and downtime, we can empower operators to focus their efforts on clean energy generation," Tan said.

Baltoflake uses glass flake materials, which are combined with polyester to develop a new structure up to 20 times more watertight than other traditional materials.

"We now have the relevant in-field data required to demonstrate Baltoflake's full asset lifecycle protection performance," Tan said.

Jotun partnered with DNV to report on the findings of the North Sea project, which was decommissioned in 2020. DNV is a trusted voice in the assurance and risk management sector. The independent operator uses data and expertise to advance safety and invent solutions for the future.

Meanwhile, sustainability is the cornerstone of Jotun's business. The company is seeking to have reduced its carbon footprint by 50 per cent by 2030.

Jotun believes paints and coatings are central to the sustainability conversation, and can play a key role in a better future.

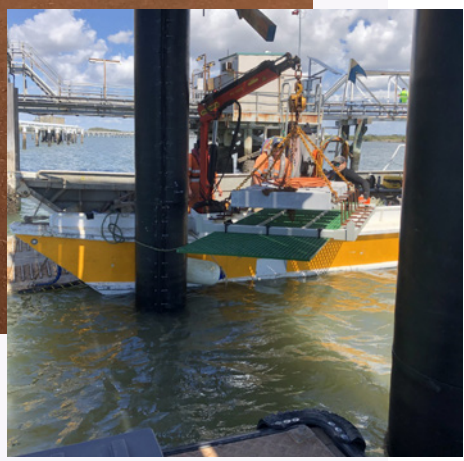
Scape Consulting Pioneers Cathodic Protection Excellence in Australia and Beyond

Scape Consulting are behind some of Australia's most successful cathodic protection and corrosion control projects. A dedicated team of professionals use their knowledge and skills to work on key deliverables covering a variety of sectors. All work is underpinned by compliance, ingenuity, and efficiency. The company is proud to operate in most Australian states and territories to deliver cost-effective solutions with the highest levels of quality.

Scape Consulting also services international clients. The Hong Kong International Airport (project P560(R)) is one of the most successful pieces of work Scape Consulting has undertaken. The airport underwent a cathodic protection design, installation, termination, and commissioning to protect the critical infrastructure from extensive damage.

Hong Kong's main airport is one of the busiest in the world. Nearly 70 flights can be handled each hour during peak times, connecting passengers to over 220 destinations. The project team were tasked with protecting the aviation fuel pipeline diversion, and the Sha Chau HDD Pipeline. The 5.2km fuel pipeline is one of the world's largest using the horizontal directional drilling (HDD) technique.

Because of the nearby waterways and local wildlife, it was crucial the Scape Consulting team and Hong



Kong Airport Authority mapped out the complexities of this assignment. A cathodic protection system was employed to maximise safety and minimise the environmental impact of the drilling. The project team were able to complete their work within three years.

On home soil, Scape Consulting are regularly engaged to provide end-to-end services of a cathodic protection system.

For example, the company has worked with local stakeholders to deliver cathodic protection installation, termination and commissioning for the Brisbane International Cruise Terminal. Wharfs, jetties and other marine areas are prone to corrosion because of their exposure to water and the natural environment. In this project, Scape Consulting was engaged by Brady Marine and Civil to provide a new layer of protection for the 200m steel pile jetty.

The project required the supply of materials and access to protect the supporting structures from the dangers of corrosion. Once the remediation works were identified, the team developed long-term maintenance solutions. In all, 105 piles, each measuring 45m, underwent a cathodic protection process. Brady Marine and Civil won in the 2020 Design and Innovation category at the Queensland Major Contractors Innovation and Excellence Awards for their delivery of this project.

Scape Consulting are an Australasian Corrosion Association Diamond Member. This is the top tier of membership, and provides members with exclusive access to events, knowledge and a community of likeminded peers.

BECOME A CORPORATE MEMBER

History of the Australian Electrolysis Committee

In 1977 there were Electrolysis Committees (EC) in Queensland, New South Wales, Victoria and South Australia, but there was only relevant legislation in New South Wales and Victoria. Draft legislation had been prepared for Queensland but it was far more proscriptive than that in the other states. To air the issue the Queensland Branch of the Australasian Corrosion Association (ACA) arranged a "Cathodic Protection Legislation Symposium" for 25 May 1977.

During the symposium there was an informal meeting between the members of a number of EC including Roy Staples (Queensland EC Chairman), Bill Woodberry (New South Wales EC Secretary), Jack Dunn (Victorian EC Convener) and Brian Byrne (ACA Electrolysis Officer). The group decided that an Australian Electrolysis Committee (AEC) be formed of members of the various state EC and that they meet on a regular basis to assist with the coordination of interference testing regulations, and to provide a forum for information transfer on interference testing and electrolysis issues. Jack Dunn was charged with convening the first meeting of the AEC, to be held during the 1977 ACA annual conference.

The first meeting of the AEC was held in Brisbane on 15 November 1977, during the ACA Conference, with Jack Dunn in the chair. The attending members were:

- Queensland (Brian Byrne, Bob Thomson)
- New South Wales (Bill Woodberry, Brian Martin, Phil Aubin, G Johnston)
- Victoria (Jack Dunn, Len Jenkins, Lindsay Wilcox)
- South Australia (Reg Casling, G Law, C Moore)

The meeting discussed interference testing regulations in the different states, and DC components from AC electrical appliances causing corrosion of buried structures.

Meetings have been held twice yearly since that first meeting in November 1977; the single exception being the Covid-cancelled ACA conference in 2021.

Secretary/Conveners of the Committee have been:

- Jack Dunn from Nov 1977 - Nov 1978.
- Brian Martin from June 1979 - Nov 1992.
- Geoff Cope from May 1993 - Nov 2003.
- Bruce Ackland from Nov 2003 - Nov 2004.
- Mark Davidson from Nov 2004 - Jan 2011.
- Alireza Kouklan from Jan 2011 to present.

Initially the Chairman of an AEC meeting was elected from the members attending that meeting, until June 1979 when Bill Woodberry was elected. Bill left the Chair during an animated discussion on 'DC components from AC electrical appliances causing corrosion of buried structures' at the November 1981 meeting. He did not return. The Chairmen since then have been:

- Len Francis from June 1982 - Nov 1983.
- Reg Casling from June 1984 - Nov 1987.
- Geoff Cope from June 1988 - Nov 1992.
- Brian Martin from June 1993 - Nov 2004.
- Bruce Ackland from Nov 2004 to present.

The initial meetings discussed interference testing regulations, interference testing procedures and electrolysis issues, especially DC components from AC electrical appliances causing corrosion of buried structures. The scope was substantially broadened in 1979 when Brian Martin arranged two full day open forums in Sydney, with lead papers from Walter von Baeckmann (Ruhrgas – Germany) and Alfred Baltes (Pipeline Engineering – Germany).

On 16 October 1979 there was the "Interference Testing Symposium" which opened a major discussion on interference testing criteria and errors in interference measurements. This initiated a research program into interference testing by the New South Wales EC, the results of which were published by Martin & Huckson in Industrial Corrosion in 1986.

On 17 October 1979 there was the "Cathodic Protection Forum" which opened a full day debate on:

- Cathodic protection in crevices under disbonded coating.
- Cathodic protection shielding on closely paralleling and intersecting pipelines.
- Telluric effects.
- Mitigation of induced AC effects.
- IR drops in potential measurement.

Most of these discussions led to research work, which has subsequently been published.

A draft Constitution was put to the meeting of June 1980 and, after some heated discussion, it was agreed that membership could be extended beyond those belonging to EC. Membership was opened to anyone interested in cathodic protection, interference testing and electrolysis matters. There were minor changes to the Constitution in June 1982, but then it remained unchanged until the AEC incorporated into the ACA as its first Technical Group in November 1993. Presently, anyone on our mailing list is considered a member, although membership of the ACA is also encouraged.

The AEC ran the first ACA conference forum in Adelaide in November 1986. Conference organisers thought that it would be a side-show for cathodic protection specialists, however it was packed, leaving the formal sessions with embarrassingly small audiences. Cathodic Protection Forums have been held at all ACA conferences since, as well as the main full day mid-year meeting. Other technical groups within the ACA now also run successful conference forums.

The global COVID-19 pandemic caused difficulties with in-person contact and online platforms helped maintain the regularity of meetings with just one being missed. The first major effort at online meetings was in Melbourne on 15th December 2020 via the web. The meeting had about 100 members attending online from overseas and all states and territories of Australia.

The mid-year meeting is the AEC's main technical event and is scheduled as a full day event with presentations and active discussions about corrosion, cathodic protection, stray currents and any other issues affecting our industry. These mid-year meetings are generally held in different states from year to year to allow as many members as possible to attend at least some of these. The next AEC meeting, the 93rd, is scheduled for Melbourne on the 29th May 2024, in person and via the web to celebrate the 47-year history of the AEC.

Vale to some of our recently deceased members; Peter Crampton, Peter Clark, Brian Cherry, John Marden, Geoff Rippingale and Gavin Forrester. Our apologies if some are not listed, but all members past and present are important to our community and we sadly miss but fondly remember all those who have passed.

Looking forward to seeing everyone in May, either in person or online.

Bruce Ackland
Alireza Kouklan

NEXT MEETING: 93rd AEC MEETING

In person at the ACA Head Office, Preston & online

Wednesday 29th May – 9am to 4pm

CLICK HERE TO REGISTER

South Australian Branch AGM

The South Australia branch held the AGM on Friday, 15 March at The Lord Melbourne Hotel in North Adelaide.

After the official part, the members and guests divided into groups of 3-4 for the traditional quiz night which is an integral part of the program in SA for years. This year Vice-President Anthony Roccisano was the quizmaster who had prepared 50 questions in 5 categories. Winners this year were the "brush strokes" with Robert Gregory, Nick May, Michael Lewis and Kingsley Brown who won $200 prize money. We thank our sponsors for this year, Tcorr and Asset Inspection Consultants.

Thank you, Dennis

Dennis Richards, an Honorary member of the ACA, recently stepped back from his role as a branch committee member in South Australia. Before he has served the branch for decades, including at least 20 years as a secretary.

Dennis has shown great commitment and passion for the branch and the ACA. He led the committee through great changes over the last few years and was a valuable advisor for the younger committee members. His experience and diligence will be truly missed. The SA branch committee wishes Dennis all the best for the future where he will focus more on his consultancy business and family.

Sponsored by:
Asset Inspection Consultants
Denso Australia
Remedy Asset Protection

NEXT EVENT:
South Australia – Stude Case Study Night
Wednesday 21st May – 6pm to 9pm

CLICK HERE TO REGISTER

Boomers claim victory at the 2024 Young vs Old(er) Barefoot Bowls

The Victorian Branch of the Australasian Corrosion Association (ACA), in conjunction with the Young Corrosion Group (YCG), kicked off 2024 with a spritely competition of barefoot bowls.

The social event saw young and not-quite-as-young corrosionists take to the Port Melbourne Bowls club to mingle, eat pizza, and compete for the trophy for the first time since 2018. After some impressive competition and a lot of laughs, the Boomer's win was set in concrete with a knockout bowl by Victorian Branch President, Wayne Neil. A fun time was had by all and we look forward to the return of the event in 2025!

VIC Branch AGM

ACA Victorian Branch held their AGM on Tuesday evening 26/3 at the ACA head office in Preston.

A highlight of the AGM was the acknowledgement of our long standing Treasurer, Richard Brodribb, who is stepping down from this position after 23 years in the role (starting 2001). On behalf of the ACA Victorian Branch, and all the current and past committee members, we would like to offer a gigantic thank you for your tireless efforts.

Preceding the formalities of the AGM, we had a technical presentation from Dr Grant McAdam of the Defence Science and Technology Group, detailing the trials and tribulations of the Australian Defence Force's path to Chromate-free primers for aircraft. This presentation was a fantastic overview of the work DSTG has done over the past few decades right through to the present day.

The upcoming events for the ACA Victorian branch for 2024 are listed below. Keep your eyes peeled for more details closer to the events.

New Zealand AGM

The AGM of the ACA NZ Branch was held at HERA House, Manukau, Auckland, on Thursday 21 March 2024. The meeting was chaired by Ry Collier, the outgoing NZ Branch President. Attendees present at the AGM were from Auckland, Taranaki, Wellington and Christchurch.

The Branch Officer reports presented to the meeting demonstrated that the NZ Branch was back in good heart again after several difficult years due to Covid.

The following people were elected as Branch Officers for 2024-25:
President: Grant Chamberlain (the VP is TBC)
Secretary: Mark Sigley
Treasurer: Willie Mandeno
Education: Matt Vercoe
Communications: Trish Shaw
Technical: Raed El Sarraf
Electrolysis: Grant Chamberlain
Membership: Hanieh Ghominejad

Other Representatives:
Branch Committee Members: Philip La Trobe, Rene Hill, Nicholas Zglobis and Ry Collier (Immediate Past-President).

Other Representatives:
ICC: Willie Mandeno, Trish Shaw
ACA Council Representatives: Grant Chamberlain, Willie Mandeno
YCG Representative: TBC
Bulletin Editor: Les Boulton

The main topic on the agenda was the Special Resolution to amalgamate the four existing NZ Divisions into a single ACA NZ Branch. The resolution was put to the meeting and it was passed unanimously.

The President's Report for 2023-24 will be published in the May Bulletin. Willie Mandeno then presented a technical talk entitled: "AS-NZS 2312.3 Metal Spray Coatings". His talk outlined the history and present situation with publication of AS-NZS 2312 Part 3, which deals with the subject of Thermal Metal Spray (TMS) Coatings.

The new standard on TMS is expected to be published in 2024.

Above: NZ Branch President Ry Collier (outgoing) and NZ Secretary Mark Sigley at the AGM

Left: Willie Mandeno presents his technical talk on TMS coatings after the AGM

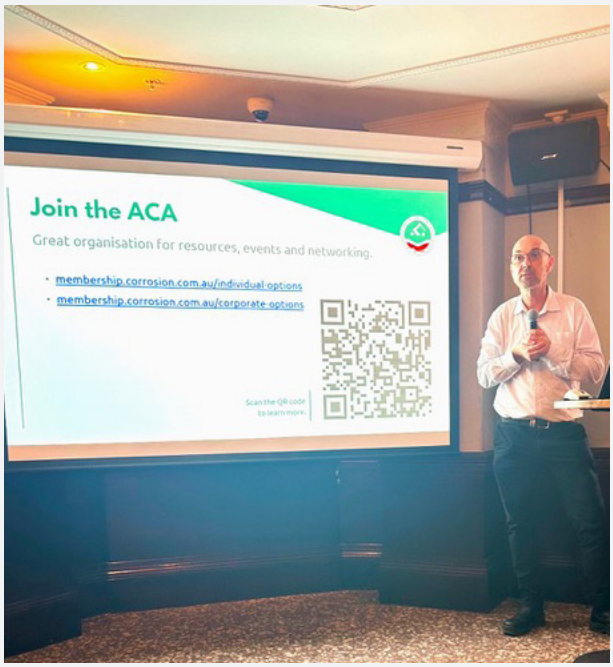
NSW Branch AGM

NSW branch held its AGM in Sydney on the 19th of February. The NSW committee welcomed two new members, Baha Mehdizadeh from UTS and Aaron Skeates from Iron Bridge Engineering.

President Adam Hockey and Vice President Felicity Smith presented the committee with a review of 2023 and the planned activities for 2024.

The NSW committee is planning 4 technical events and 4 lunch and learn presentations for 2024 and will also work closely with YCG in their planned activities.

The committee also discussed its current relationship developments with Universities and the NSW Construction Industry.



Newcastle Branch AGM

The ACA Newcastle Branch held their AGM on 12 March 2024.

- Igor Chaves, Councillor
- Jim Hickey, Councillor
- Andrew Dickinson, Committee member
- Dave Blackaby, Committee member
- Craig O Brien, Committee member
- Bruce Leitch, Committee member
- Zach Arneil, Committee member
- Rhett Watters, Chair

Following the formalities, the group took an opportunity to reflect on the year that was in 2023 and acknowledge the great work of last year's committee in organising several technical events, including facility tours, stainless steel and protective coatings, as well as a collaboration with the University of Newcastle for a live demonstration.

Finally, event planning for this year was discussed which will prove to be another strong year for local technical events, with a reinforced concrete assets seminar scheduled for May and a site tour planned for September.

Queensland Branch AGM

The ACA Queensland Branch held its annual AGM function at the Aspley Tavern function rooms on Thursday 21.3.24. The event was well attended with almost 20 members and representatives from industry.

The AGM was preceded by a presentation from sponsors for the evening Baseline and Everything Water. Dr Steven Nearhos presented the technology his team has developed in monitoring and removing the influences of bacterial and microbiological bacteria. A very unique and interesting discussion for All who attended.

Rowan Dann from Everything Water discussed the extreme difficulties they experienced in designing and commissioning the necessary filtration equipment on the roofs of high-rise buildings with limited access as well as minimal plant room space.

The AGM saw the election of Ben Biddle as incoming branch president and Alister Verth as Branch senior vice president. Joseph Davies as Branch YCG representative met with a number of young participants who attended the meeting to explain the benefits of participation in the YCG group.

We all look forward to the fresh energy that will be created by the new committee. Following some refreshments and eats, plus a degree of networking, the evening finished on a positive note.

SAVE THE DATE: In Person Technical Event

AI in corrosion – further details to come

Queensland - June 2024

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- ***Influence*** *the Industry*
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2024 FEATURES

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CONTENTS

Dr. Ing. Christiane Shultz, President, SA Branch

Dr.-Ing. Christiane Schulz is a surface engineer with a focus on solving industry problems. She has 10 years of hands-on experience in the coating processes laser cladding and thermals spraying which are used to apply thick metallic and ceramic coatings. Her research interest is wear and corrosion resistant coatings in heavy industries like mining, energy, steel, agriculture and offshore.

Q1.

Where do you work? Describe your job.

I am working as a Technical Product Manager for LaserBond Ltd. LaserBond is a surface engineering company specialised in thermal spraying and laser cladding for the application of wear and corrosion resistant coatings for OLEM and repair. In my role I act as a link between sales, marketing, R&D and production. In essence, my job is technical sales support to make sure that the customer gets the most suitable coating for their application. I like that my position is so versatile, and I am doing something different every day. This can range from selecting a FDA approved coating for an application in pet food processing, over writing a marketing brochure for hardchrome replacement to certifying an Additive Manufacturing repair method for a capital-intensive components in in the mining industry.

Q2.

Can you share your journey into the corrosion industry? What motivated you to become involved?

When I was looking for my first job in 2009, after returning to Germany from an 18 months backpacking trip through Australia, industry wouldn't hire because it was the height of the GFC. That's how I ended up doing my PhD. The project I was hired for was about thermal spray coatings for corrosion protection of offshore-wind turbines. So, I had to learn about corrosion for the project and for my lecturer role for the Master's course "Corrosion and Corrosion Protection".
What motivates me today is, that I believe, corrosion protection can really have an impact in terms of sustainability of our planet.

Q3.

Who or what has influenced you most professionally?

My materials science professor, Prof Alfons Fischer, now Editor in Chief of the journal "Wear". When I had to decide in my 3rd year at uni what specialisation I should pursue, I was interested in process engineering and materials engineering. First, I had a meeting with the process engineering professor who said to me: "You, as a woman, will have to find a job where you can work part time. Perhaps, a job with the council would be for you?" Whereas Prof Fischer said: "I have this project with Rush University in Chicago coming up. Would you be interested to study in the US for 6 months and work on wear behaviour of artificial hip and knee implants?" And, that's how became involved in materials and wear and corrosion protection.

Q4.

What has been the most challenging project you've worked on and why?

The biggest challenges in projects are usually not the technical problems. What make a project challenging are politics, lack of communication and difficult collaboration partners.

Q5.

What do you see as the biggest challenges facing the corrosion industry today?

The biggest challenge lies in convincing decision makers to use a "new" corrosion protection strategy. I say "new" because even technology that has been proven for decades overseas is seen by many as too risky to be tried in Australia. Unfortunately, no one wants to be the first, but rather the first to be second. The other challenge is, getting past procurement officers who don't understand that the more expensive option will be cheaper over the service life of a structure or component.

Q6.

Have you noticed any emerging trends in corrosion that the industry should be aware of?

Hardchrome coatings are widely used for components that require wear and corrosion protection, such as hydraulic cylinders in mining or marine applications. Hardchrome coatings are applied with an electroplating process that uses hexavalent chromium (ChromeVI58

) which is a known carcinogen. Because of health and environmental concerns hardchroming is already heavily restricted in Europe, the US and China. It is expected that electroplating of chrome as a coating process will be phasing out in the next 5-10 years. If you are using hardchrome coatings, you should look for alternatives now. Thermal spraying and laser cladding are proven replacement technologies with superior resistance in most applications.

Q7.

Where do you see the future of corrosion mitigation and management heading in the next decade?

In terms of asset management, I see the trend going to 100+ years design life. We know that our buildings and bridges need to last in order to be sustainable and cost-effective.
From a coatings perspective, 100+ years can only be achieved by combining active, cathodic coatings, Zn-and Al-based, with organic top coats to harness the synergistic effect of combining both coating technologies.

Arthur Kokolekos, Oil, Gas and Energy Technical Group Chair

Arthur has over 30 years' experience in the roles of service, sales, applications and product management, specifically in the municipal and industrial sectors in his home country of Australia and the wider Asia Pacific region. His passions are finding solutions to customer problems that deliver value to their processes and operations. In his current role as Business Development Manager at LuminUltra Technologies, Arthur is educating the Asia Pacific market on the costs and damages associated from microbial threats in industries and the community as a whole.

Q1.

Can you briefly describe your background and how you came to specialise in corrosion?

Like many things a mix of coincide and luck. Having worked in the water and wastewater sector microorganisms are bad and good respectively. My work in these industries translated into the oil and gas industry where microorganisms through Microbial Influenced Corrosion (MIC) is a serious issue to assets, infrastructure, and product quality.

Q2.

Can you tell us about your current role?

I'm currently the regional business development manager for the APAC region for LuminUltra Technologies from Canada. LuminUltra Technologies is a global leader in rapid microbial monitoring solutions with an emphasis on providing tools to help manage microbial threats in multiple industries including oil & gas. In my role I'm responsible for educating and assisting users and partners throughout Australia, Asia and the Pacific regions.

Q3.

In your opinion, what makes corrosion a critical issue for the oil and gas industry specifically?

There are many studies globally that show the cost of corrosion is in the trillions of US dollars. While eliminating corrosion in the Oil and Gas industry would be a wonderful achievement, the reality is eliminating completely is unlikely but through understanding and education there are a multitude of opportunities to reduce these costs.

Q4.

What are the most significant corrosion challenges facing the oil and gas sector today, and how do they impact operations and safety?

All corrosion related issues in the oil & gas sector no matter what the mechanisms may be can have potentially serious impacts to operations and safety. Unchecked and not managed corrosion related incidences can impact assets and thus operations. In catastrophic circumstances these have the potential to impact the safety of workers at these various facilities.

Q5.

Could you discuss any new technologies or materials that have emerged recently to combat corrosion in oil and gas infrastructure?

My speciality is in the monitoring and from this small part of corrosion management, leveraging the power of DNA based molecular monitoring tools is an emerging methodology being employed and adopted by industry. A robust microbially influenced corrosion (MIC) management plan is underpinned firstly with data. DNA based molecular monitoring provides users with more detailed information on their potential for MIC and with considerably faster time to result than traditional tools employed to date.

Q6.

What are the key strategies for corrosion prevention and management that companies in the oil and gas industry should implement?

My answer may seem simplistic, but I believe the best starting point is being educated, informed and inquisitive. Through my membership at the Australasian Corrosion Association, it's opened up my understanding of the different mechanisms of corrosion in the industry. I've also discovered that there are many resources and clever people available to the industry to help educate and assist our industry. Addressing corrosion issues needs to start with a plan. At the forefront this should be a proactive management plan to minimize and mitigate corrosion. There will invariably be instances where eliminating corrosion may not be possible, but I strongly believe and received feedback that the costs of being proactive are considerably less than the costs associated with having corrosion problems.

Q7.

Can you elaborate on the environmental and safety risks associated with corrosion in oil and gas operations, and how these risks are managed?

High pressures, high flows, big pipes and large machinery. These are just some of the typical conditions and structures at Oil and Gas operations. From a safety perspective damage caused by corrosion related issues can quickly turn operations into a hazardous workplace. It's unfortunate that we have seen too many such instances globally. By the very nature of the products we're dealing with and our heightened awareness of the environmental impacts the same corrosion related issues can cause, a focus on preventative tools and actions in a must for the industry. In the main the industry is well aware and cognisant of the both the environmental and safety risks. A multi-faceted approach of engineering, preventative coatings, measurement, inspection and more serve as a robust and complete corrosion management plan for managing these risks.

Q8.

Where do you see the future of corrosion research and technology heading in the context of the oil and gas industry?

For as much as we know about corrosion, there is still lots we don't know. Continued research helps us address these gaps. I was pleasantly surprised at the recent ACA Corrosion and Prevention Conference to sit in on many papers presented by researchers both in Oil and Gas and many other industries. Also quite buoyed to see a lot of this research was in collaboration with industry partners. This to me is an indicator of the needs of industry, to address their challenges and a reaffirmation of the talent available to industry through the researchers and research groups. The industry benefits in all aspects of both processes and safety through continued research.

Q9.

What advice would you give to companies in the oil and gas industry to better address corrosion challenges?

One thing I've learnt in my journey at the ACA and in the Oil and Gas industry is that basically everyone faces the same challenges. The Oil and Gas Industry can at times be quite guarded about their challenges. I heard may times at the Corrosion & Prevention conference almost pleas to the industry to share their data. With this information researchers and suppliers alike can help progress and develop solutions for the benefit of the entire industry

Q10.

Could you share a specific case where innovative corrosion management significantly improved an oil and gas operation's efficiency or safety?

At our Oil & Gas Forum at the recent ACA Corrosion & Prevention Conference a representative of PTTEP from Thailand presented her case study on the use of rapid microbial monitoring methods adopted for the original core purpose to mitigate corrosion of their pipelines that was causing environmental damage to landowners and their crops. Their traditional methods of microbial monitoring for MIC risk took up to a month for results. This timeframe for feedback made the challenges of managing corrosion in their pipelines difficult. With rapid results they were able to better manage the MIC risk that provided a two-fold result in 1) reducing their pipeline damage through MIC and 2) protecting the landowner's property and environment. This was an excellent presentation noting many of my previous comments. No matter where in the world, the industry shares the same challenges. Being inquisitive and adopting new technologies different to their incumbent delivered positive results in many areas of their business. The positive outcomes solved their initial environmental challenges caused by corrosion but also realized tremendous cost savings to their business. The positive outcomes were unpinned by a plan and strategy to not only solve their existing challenges but for implementing in other areas of their business. All in attendance I believe where quite astonished with the cost savings presented.

Q11.

How are data analytics and predictive maintenance being utilized to address corrosion-related issues in the industry?

We're seeing in all facets of life and industry the adoption of data analytics and more increasing Artificial Intelligence. Why not leverage and utilize the same when it comes to corrosion-related issues in our industry? I believe this exists because it fills a gap in our industry. I've been taught, the more information you have the better decision you can make. At the Corrosion and Prevention Conference there were many suppliers showing off their latest products including smart sensors for immediate online monitoring for corrosion. Such rapid data helps the industry understand what is happening in their processes from a corrosion perspective with abundantly more information. Worldwide trends show that more and more manufacturers are adopting the AI revolution to enhance the information to users for better decision-making; if not automated decision-making. Ultimately data analytics and predictive maintenance can address the core pain point of corrosion to the industry – the trillions of dollars in cost of corrosion.

Austin Bennett

Austin Bennett is a Business Development Manager at Universal Corrosion Coatings with over 4 years experience in the corrosion industry with a keen focus on corrosion prevention coatings. I have experience in multiple sectors including but not limited to oil & gas, water, marine and defence. I have a passion for helping other young professionals network and collaborate with the rest of the industry which is demonstrated in my multiple years of service in various "young professional" committees across a range of sectors across the country.

Q1.

What is your Company or University name?

Universal Corrosion Coatings

Q2.

What is your job title/what are you currently studying?

Business Development Manager

Q3.

What is the YCG?

The Young Corrosion Group is the youth arm of the ACA. Our mission is to get younger members (under 35) of the corrosion community more involved in the industry through means of networking events, technical presentations, upskilling opportunities and social catch ups.

Q4.

Why are you a member of the YCG?

I decided to become a YCG member because I wanted to get to know likeminded people in the industry and expand my skills. I first became involved in the Victorian branch of the YCG back in 2020 as a committee member, since then I have become the Victorian branch YCG Chair as well as the National YCG chair. My main goal is to ensure the strength and continued survival of the ACA's YCG and am currently working towards reviving the National YCG Steering Committee which will meet to discuss how the YCG can be improved as well as areas where we can grow the presence of the YCG across Australasia. I have already made some great friends through the YCG and look forward to assisting with the continued development of the youth arm of the ACA.

Q5.

What are some important corrosion related issues facing your industry today

One of the biggest corrosion related issues that I face as a coatings supplier is improper product application. In pipeline coating applications, issues can arise from poor coating implementation, unsafe practices, equipment mishandling, overspray and waste — the risks of which are increased if the applicator has not received proper training. While these problems can lead to huge financial, legal and environmental costs for businesses, in-depth industry training is emerging as a simple solution. Being the Australian distributor of Seal for Life's market leading product range – Canusa-CPS epoxies, heat shrink sleeves and visco-elastic tapes, I work daily with clients as well as the technical team at Seal for Life to provide industry leading product application training to contractors and asset owners across the country to ensure the quality outcome of product application.

Q6.

How does the ACA and YCG support young people in the corrosion industry?

The ACA and YCG supports young people in the industry by providing a positive and professional space to converse and share knowledge. The corrosion industry is quite niche and I for one know that people outside of the industry might not be as invested in the issue that is corrosion. The YCG offers a community where likeminded young members can network and grow your connections. Attending YCG events across the country is an invaluable way to expand your network and develop your skills as a young corrosionist.

Q7.

What is your ACA membership level:?

I am part of a corporate membership

NATIONAL WEBINAR

YCG Sustainability Webinar

Thursday 9th May – 5:30pm to 6:30pm

WESTERN AUSTRALIA

YCG Strike Bowling

Friday 31th May – 5:15pm to late

2024 Training Calendar

AMPP Coating Inspector Program Level 1	
Victoria:	8 to 13 April
Newcastle:	15 to 20 April
Western Australia:	19 April to 4 May
New Zealand:	8 to 13 July
Newcastle:	8 to 13 July
Western Australia:	15 to 20 July
New Zealand:	22 to 27 July
Tasmania:	14 to 19 October
Cairns:	18 to 23 November

AMPP Coating Inspector Program Level 2	
Victoria:	15 to 19 April
Western Australia:	6 to 10 May
New Zealand:	15 to 20 July
Newcastle:	15 to 19 July
Western Australia:	22 to 26 July
South Australia:	2 to 6 December

AMPP Cathodic Protection Level 1 Tester	
Queensland:	13 to 17 May
Western Australia:	15 to 19 July
New South Wales:	26 to 30 August
New Zealand:	14 to 18 October
Cairns:	28 October to 1 November

AMPP Cathodic Protection Level 2 Technician	
Queensland:	20 to 24 May
Western Australia:	22 to 26 July
New Zealand:	21 to 25 October
Cairns:	4 to 8 November

ACA Corrosion Technology Course	
Victoria:	20 to 24 May
New Zealand:	25 to 29 November

ACA Coating Selection and Specification	
Online:	17 to 19 June
Online:	21 to 23 October

ACA GAA Hot Dip Galvanizing Inspector Program	
Western Australia:	16 to 17 July
New South Wales:	17 to 18 September

AMPP Corrosion Under Insulation	
Online:	16 to 19 September
Cairns:	18 to 21 November

AMPP Cathodic Protection Level 3 Technologist	
Online:	29 April to 3 May

ACA Cathodic Protection Authorised Tester	
New South Wales:	9 to 10 May

AMPP Concrete Coating Inspector	
Victoria:	13 to 17 May

AMPP Cathodic Protection Level 4 Specialist	
Online:	17 to 21 June

ACA ACRA Concrete Structures and Buildings	
Online:	25 to 26 July

Course Spotlight:
AMPP Coating Inspector Program Level 1

The AMPP Coating Inspector Program – Level 1 (CIP1) course is an intensive presentation of the fundamental technology of coating application and inspection. It provides both the technical and practical fundamentals for coating inspection work on structural steel projects. This is the world's most recognised and specified coating inspection certification program.

Although specifically designed for Coating Inspector Trainees, this program benefits anyone interested in gaining a better understanding of coatings and inspection including Project Managers, Engineers, Maintenance and Quality Assurance and Control Personnel, Contractors and Specification Writers, and Coating Applicators.

Course highlights:

- Coatings Introduction
- Curing Mechanisms
- Role of the Inspector
- Environmental Test Instruments
- Inspection Procedures
- Non-destructive Test Instruments
- Coating Specifications
- Application Procedures
- Surface Preparation and Standards
- Coating Failures
- Field Lab
- MSDS and Product Data Sheet Review
- Logbook Documentation
- Non-destructive Testing and Inspection

More information & Registration

3D Printed Titanium Structure Shows Supernatural Strength

RMIT researchers recently created a metamaterial from a common titanium alloy. Tests showed the material's unique lattice structure design is 50 per cent stronger than the next strongest alloy of similar density.

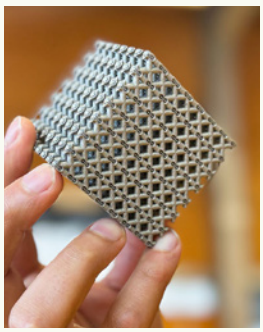
RMIT's Distinguished Professor Ma Qian said decades of trying to replicate the hollow 'cellular structures' in metals has been frustrated by the common issues of manufacturability and load stress.

"Ideally, the stress in all complex cellular materials should be evenly spread. However, for most topologies, it is common for less than half of the material to mainly bear the compressive load, while the larger volume of material is structurally insignificant," Qian explained.

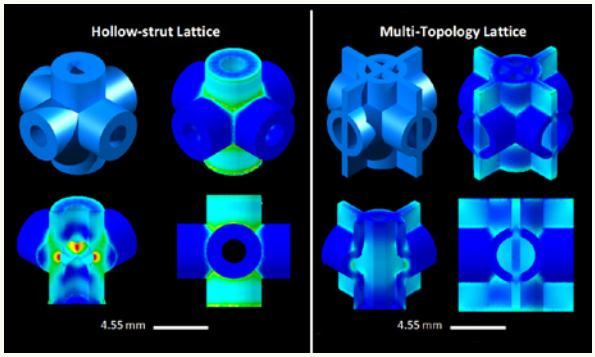
Metal 3D printing provides unprecedented innovative solutions to these issues, particularly surrounding the threat of corrosion. By pushing 3D printing design to its limits, the RMIT team optimised a new type of lattice structure to distribute the stress more evenly, enhancing its strength or structural efficiency.

"We designed a hollow tubular lattice structure that has a thin band running inside it. These two elements together show strength and lightness never before seen together in nature," said Qian.

The team printed this design at RMIT's Advanced Manufacturing Precinct using a process called 'laser powder bed fusion,' where layers of metal powder are melted into place using a high-powered laser beam. This printability, along with the strength, biocompatibility, corrosion and heat resistance make it a promising candidate for many applications from medical devices such as bone implants to aircraft or rocket parts.



Left: A sample of the new titanium lattice structure 3D printed in cube form. Below: Compression testing shows (left) stress concentrations in red and yellow on the hollow strut lattice, while (right) the double lattice structure spreads stress more evenly to avoid hot spots.



Left: Professor Martin Leary, Professor Ma Qian, Jordan Noronha and Professor Milan Brandt at RMIT's Centre for Additive Manufacturing. All images courtesy of RMIT.

Applicators & Coatings 2024 ROADSHOW

Christchurch | Auckland | Sydney | Perth

Presented by:

Applicators Technical Group

Coatings Technical Group

THE EVENT

The Applicators and Coatings Roadshow is a joint event delivered by our Applicators and Coatings Technical Groups. This will be a fantastic opportunity to bring the industry together, raise awareness of new technologies, maintain and develop new Standards, support training opportunities and more!

WHAT'S ON

Technical Presentations

Industry experts are bringing their wealth of knowledge to our show. Guest speakers are presenting their work in Coatings, Concrete Protection, Application Techniques, and more.

Social gathering

The Roadshow is also a great opportunity to network with industry peers. Your ticket includes snacks, lunch, refreshments. Don't miss the networking event in Gladstone on 8th June!

Forums and Q & A Sessions

Corrosion specialists will share their knowledge and experience in Question & Answer sessions where attendees are encouraged to participate.

Applicators Technical Group

The **ACA Applicators Technical Group** aims to represent the needs of specialist contractors in industries that serve the protection or restoration of corrosion affected structures throughout Australasia. These include companies and individuals in concrete protection, applied concrete floor finishes, concrete repair, hazardous coating removal, surface preparation and coating application.

Coatings Technical Group

The **ACA Coatings Technical Group** shares ideas, project studies, technologies and market trends amongst asset owners, designers, manufacturers, suppliers and equipment providers to the protective coating industry that serve the protection or restoration of corrosion affected structures throughout Australasia.

Into The Deep: Monash At Forefront of Australian Nuclear Materials Research

A recent study that will help nuclear-propelled submarines to remain underwater—and undetected—for much longer, has put Monash researchers in the global spotlight.

The research identified a critical corrosion mechanism of nuclear fuel cladding material that is affected by how the material is processed.

Corrosion is a huge financial burden globally, costing an estimated $US2.5 trillion each year.

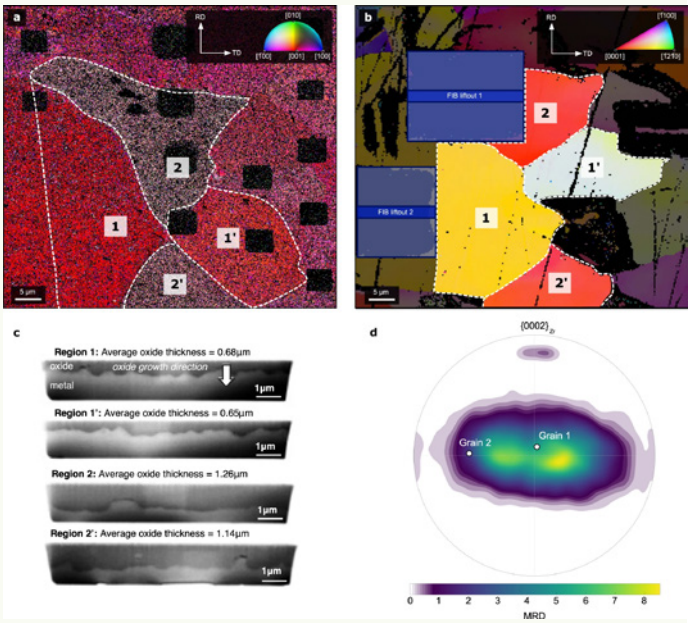
In nuclear submarines, the ultra-thin material, zirconium alloy, provides a barrier between the nuclear fuel and the water surrounding it. Until now, it has been difficult to accurately predict the lifespan of the cladding, wasting time, resources and potentially, millions of dollars.

"Nuclear submarines are expected to run for 25 years without refuelling, which contributes to them being highly undetectable," said lead author Professor Michael Preuss. "In order to achieve this it is important to ensure that the life of the material encapsulating the nuclear fuel can be predicted."

The research developments come as discussions heat up over AUKUS, which is the trilateral security pact between Australia, the UK and the US.

Professor Preuss said the study's findings are a timely reminder that Australia must do all it can to begin growing the skills needed to maintain, and eventually build, nuclear submarines.

"Australia is facing an unprecedented challenge in developing a skill base in nuclear within 15 years in which Australian universities will have to play a key role," he said. "And it won't just be in one or two universities because the challenge is massive."



EBSD orientation maps in inverse pole figure colouring relative to ND for a monoclinic ZrO2 and b corresponding metal grains after mechanical removal of oxide. Oxide regions and metal grains for subsequent orientation analysis are labelled as 1, 2, 1' and 2'. Original rolling (RD) and transverse (TD) directions are marked on the figures. FIB liftout positions for SPED analysis from regions 1 and 2 are shown in b. SEM images acquired from FIB trenches from each oxide region are shown in c, where the oxide growth direction has been shown for region 1 and is the same for the other regions. Square regions (~5µm) visible in the oxide orientation map are regions of intentional focused-ion-beam (FIB) damage that formed part of another study11 and are excluded from this analysis. d <0002>Zr pole figure showing the typical 'split-basal' texture of single-phase Zr alloys (Zircaloy-4) measured using electron backscatter diffraction (EBSD), with the orientations of metal grains 1 and 2 marked. Colours represent intensity in units of MRD (multiples of a random distribution).

A Combination of Two SeaShield Systems used to Protect Steel Piles

Sub sea splash zone coating by Denso. Image Credit: Denso.

Denso Australia recently completed a project involving the use of SeaShield 2000FD and SeaShield 100 systems. Together, these multi-layered systems offer unmatched potential for the protection of concrete and steel piles.

The project involved pile wrapping of close to 30 steel piles in NSW, with various diameters and lengths of coverage.

In addition to wrapping the facility's mooring and fender piles, several of the piles had a range of modern repositioned mooring hooks and fender brackets incorporated into their design.

With the mooring hooks and brackets creating an obstruction on several of the piles, the scientists understood the SeaShield 2000FD system would not be the sole corrosion protection solution required.

In this instance, the piles required a combination of the two SeaShield systems to be used together. As such, the SeaShield 100 system was applied to cover the areas of the piles in which the SeaShield 2000FD system was unable to be cut, or modified to protect.

This recent project not only marks the first time Denso Australia's two SeaShield systems have been used together in this way, but is yet another showcase for the innovative 'made-to-measure' solutions the company provides for its clients.

This project was successfully completed within the allocated time. Additionally, the contractor also relayed the asset owner's elevated level of satisfaction with both the final appearance of the SeaShield application, and the overall outcome.

Denso Australia are specialists in the manufacture and supply of corrosion resistant coatings. The company collaborates with clients who host steel, concrete and timber surfaces.

Microbiologically Influenced Corrosion — Joint Industry Project Phase Two

Microbiologically influenced corrosion (MIC) constitutes a significant threat, which compromises the integrity of pipelines and equipment across various industry sectors. MIC silently corrodes metal substrates. This results in rapid and localised deterioration.

In 2021, Curtin University's Corrosion Centre launched a joint industry project, designed to establish a collaborative framework between industry and academia.

This partnership favours the transfer of knowledge and the application of demand-driven research to tackle MIC challenges.

During phase one, the team worked on improving MIC assessment methodologies. Over the course of this phase, the alliance developed two innovative prediction models using artificial intelligence.

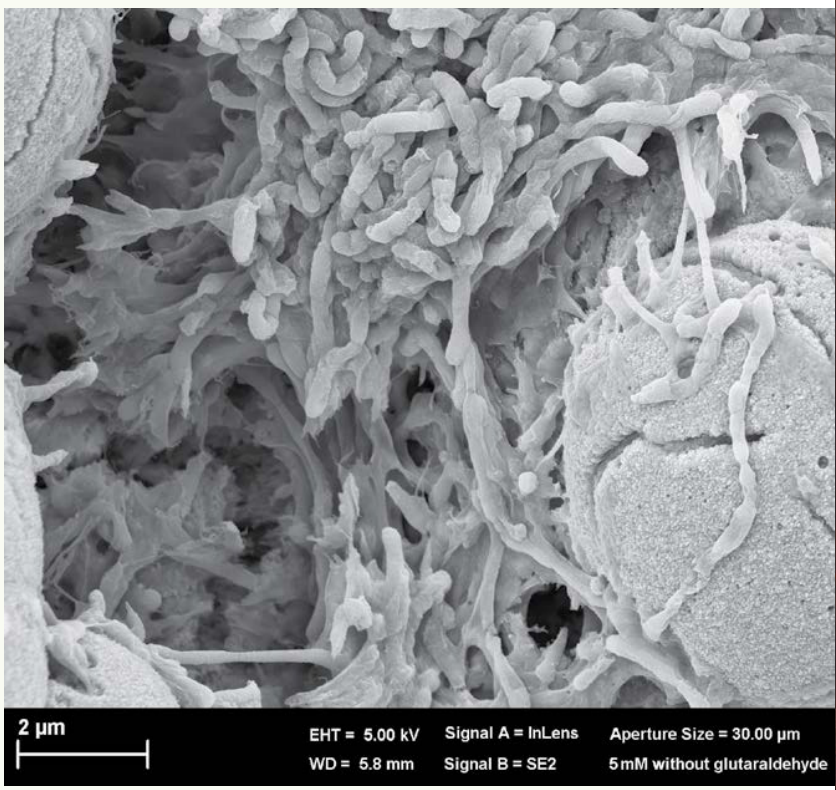
These models serve to assess the probability of biofilm formation and MIC potential in industrial assets. This provides a robust foundation for predictive maintenance strategies.

The research team emerged as pioneers in advancing molecular methods used to characterise microbial communities in natural samples. By doing so, researchers successfully mitigated the risks associated with under or over-estimation of MIC potential. Together, this enhanced the precision and reliability of the assessments.

Researchers have recently begun their work the second phase of the program (MIC-JIP Phase 2). This research program relies on industry partners to join the established and collaborative team dedicated to strengthening resilience against MIC-related challenges.

It is believed the most recent MIC-JIP phase will persist in its commitment to developing innovative tools and methodologies for predicting, diagnosing, and monitoring MIC.

The program is expected to last three years with a provision to extend for a further two years. Curtin University will sponsor one PhD scholarship as part of this program.



Carbon steel covered with a copious biofilm of Shewanella oneidensis. Image Credit: Curtin University's Corrosion Centre.

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- **Quality Content:** Benefit from association with our high-calibre articles, case studies, and industry insights. Your brand will be in good company.
- **Extended Reach:** Beyond the page, your message resonates. Our journal amplifies your visibility, reaching a wide audience of professionals.
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CONTENTS

WSP Recognised in Top 100 Graduate Employers in Australia

Image courtesy of WSP

WSP was recently named one of Australia's top 100 graduate employers in Australia. The company was recognised by Prosple, a platform dedicated to helping every student to get the best possible start to their career.

WSP was ranked 16th in Australia's top graduate employers, an increase from 22nd in the year prior. The firm has been ranked in the top 100 by Prosple (formerly GradAustralia) for the last two years.

WSP offers opportunities to do the kind of work the world needs with a suite of unlimited opportunities. Around 130 graduate positions are on offer across transport and infrastructure; property and buildings; earth and environment; water, mining and energy; advisory and digital, and communications and engagement.

WSP believes the range of opportunities provides endless graduates with a stepping stone to make a meaningful contribution to communities.

WSP boasts approximately 6,000 talented people in 14 offices across Australia. There are also opportunities to work with WSP globally.

The WSP experience ensures participants can build diverse expertise that benefit careers, colleagues and clients. It offers a comprehensive pre-onboarding program for graduates, prior to starting with the business.

The WSP Graduate Program is a two-year blended learning experience, offering a comprehensive approach to development. It includes topics specifically chosen to enhance professional, personal and relationship building skills.

There is also an Emerging Professionals Network, which seeks to provide opportunities to professionally develop and connect staff with up to 10 years' experience across Australia. The network is open to all positions, locations and employment types.

WSP is a Platinum member of the Australasian Corrosion Association

AkzoNobel Completes Expansion of Its Largest Powder Coatings Plant

AkzoNobel's Powder Coatings site in Como, Italy, recently completed a major capacity expansion.

The opening means four modern manufacturing lines are operational following the €21 million project. Two manufacturing lines are dedicated to automotive primers, while the other two focus on architectural coatings.

A range of innovative bonding equipment lines have also been added. This ensures the products meet and exceed industry standards.

"Increasing our capabilities in Como is a significant milestone which supports our ambition to create safety of supply for our customers," said Sanal Limoncuoglu, who is the Commercial Director of AkzoNobel's Powder Coatings business in South and East Europe and Middle East Africa.

"We're now well equipped to serve all our customers in the EMEA region with highly efficient lines that are state-of-the-art in terms of consistency and quality."

The extra capacity has been installed in a renovated building where powder coatings were originally made. This is a sustainable reuse of an existing part of the site, which was established in 1992.

Meanwhile, the new lines also use recycled energy to meet the highest standards in sustainable production. This is in line with the company's ambition to reduce its carbon emissions by 50 per cent by 2030.

AkzoNobel's Como site is the company's largest plant for producing powder coatings.

It supplies products for seven main market segments: home appliances; architecture; automotive; agriculture and construction machinery; trade coaters; furniture; and general industry.

Akzonobel completes expansion of its largest powder coatings plant. Image Credit: Akzonobel.

Major Changes to Construction Code Set to Improve Corrosion Protection

In Australia, many houses located close to the coastline are susceptible to corrosion. When crashing surf with a high salt component is swept into the air, the windblown salt often lands on buildings, increasing the corrosion risk.

However, breakthrough science means engineers can choose from a range of well-defined steel coating solutions and provide a higher level of corrosion protection.

Peter Golding (CEO, Galvanizers Association of Australia) said there was a limited range of products on the market to protect from corrosion.

"Under the previous National Construction Code, many of these homes were sometimes not sufficiently protected from corrosion."

"We were seeing homeowners, particularly in coastal areas, potentially living in homes that were not fit-for-purpose. Although the buildings were compliant with the code, builders didn't always provide a solution that was suitable for the environment."

Golding said the products listed in the code did not previously provide suitable corrosion protection in many common applications.

"There were only two options: close to the coast and far from the coast. Engineers could have a valid design that only gave the homeowner five years of protection when a house was close to breaking surf."

However, recent changes to the code have been introduced to rectify these problems and provide a better path forward for corrosion protection.

"The building code for residential housing is now much clearer and consistent with all other codes. This means an engineer who is designing a residential house can follow the well-established path for selecting a suitable product," Golding said.

Sun-Derperfoming?
Why A New Wave of Solar Panels May Lose Their Spark Too Soon

The newest photovoltaic systems may promise to be the most efficient ever produced, but question marks about their longevity mean they risk proving to be a false economy.

The photovoltaic (PV) industry has been intensely focused on increasing the efficiency modules and making the electricity generated more affordable. To sustain efficiencies, the industry has been transitioning from traditional Passivated Emitter and Rear Contact (PERC) solar cells to more advanced technologies.

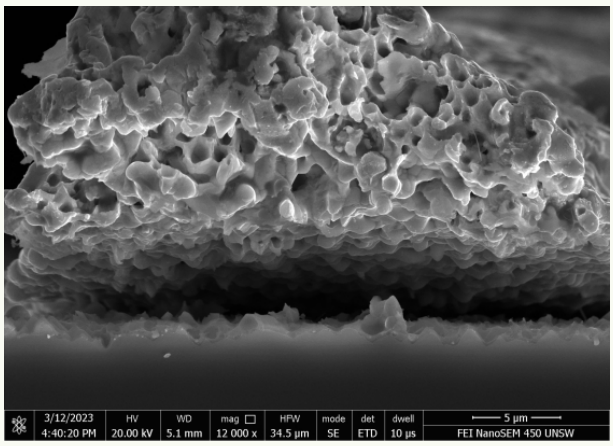
The latest technologies are called Tunnel Oxide Passivated Contact (TOPCon) and HeteroJunction Technology (HJT). However, this generation of cells introduces a series of reliability challenges, primarily because of their sensitivity to contaminants and light.

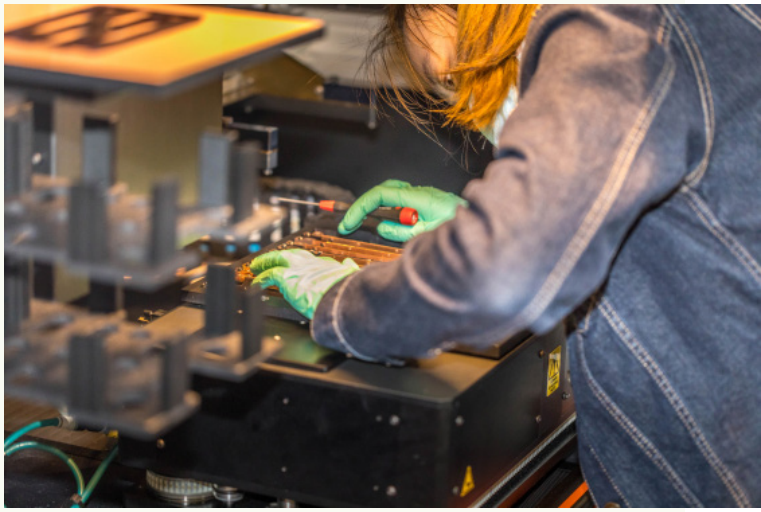
Research by UNSW and other institutions recently found inherent vulnerabilities in TOPCon and HJT solar cells, especially concerning metal contacts and thin films. Many of these potential failure modes are not detectable by standard industry testing and could drastically diminish the performance of these systems in real-world applications.

It means there could be a performance decline of over 50 per cent in just a few years. The challenges faced by TOPCon and SHJ (Silicon Heterojunction) solar cells fall into two main categories.

Firstly, TOPCon cells have front contacts that are highly susceptible to corrosion from various contaminants, especially when water penetrates the module. Secondly, the thin films used in both TOPCon and HJT solar cells exhibit sensitivity to light exposure.

These methods provide insights up to a hundred times faster than traditional accelerated testing used in the photovoltaic industry.





Top: Scanning electron microscopy image of a failed metal contact at the front of a TOPCon solar cell after accelerated testing. The metal contact has detached from the silicon due to a reaction with sodium. Above: A UNSW researcher measuring the current-voltage characteristics of an industrial TOPCon silicon solar cell. Images: Bram Hoex.

Hempel Introduces Carbon Footprint Data on Product Data Sheets for Customer Transparency

In an industry first, Hempel recently introduced a carbon footprint metric on its Product Data Sheets.

The 'Carbon Footprint Data' has been included on the Product Data Sheets of over 160 products, spanning the marine, energy and infrastructure assortments. It will enable customers to easily compare products based on sustainable outcomes.

They follow Hempel's Sustainability Product Scorecards, which are designed to measure the overall environmental impact of various paint systems quickly and easily. A comprehensive evaluation of the sustainability issues facing the coatings industry resulted in the selection of eight metrics, which are included in the Scorecard.

These Scorecards are available for all of Hempel's products. It means customers have sustainability decision-points when deciding on the best Hempel solution for their business.

"Sustainability is not only our journey," said Monica Li Avram, who is the Director, Solution Management—Infrastructure at Hempel.

"We see an increased number of requests from our customers on detailed sustainability data on our solutions, both as a requirement for their projects, or as a differentiator."

The scope of the carbon footprint on the Product Data Sheets includes raw materials, in-bound transport to the Hempel factory, manufacturing processes, and any Volatile Organic Compounds (VOCs) emitted during and after the application of the product.

"We have been providing our customers with the Carbon Footprint Data related to their annual spend or a specific project for a while now. It was a natural next step to include the information directly on our Product Data Sheets," she explained.

Cortec Solutions Solve Corrosion During Hydrotesting

Hydrotesting of industrial pipes, valves, and other vessels presents an irony. While hydrotesting is done to ensure no leaks are present and the vessel will hold up under expected operating pressures, it also raises the risk of corrosion by introducing moisture to the system.

The same water that proves the vessel is not compromised can be the very cause of corrosion that deteriorates the metal and leads to leakage over time.

In light of this, Cortec has pioneered the VpCI-649 Series for hydrotesting.

VpCI-649 is a unique concentrated liquid formulation that combines contact and vapor phase corrosion inhibitors. These inhibitors form a molecular protective layer on metal surfaces below and above the water level. It protects both ferrous

and non-ferrous metals, including copper, steel, galvanised steel, aluminium, and cast iron.

The VpCI-649 BD contains an organic-dispersing agent, and VpCI-649 Winterised provides protection against product-freezing during storage.

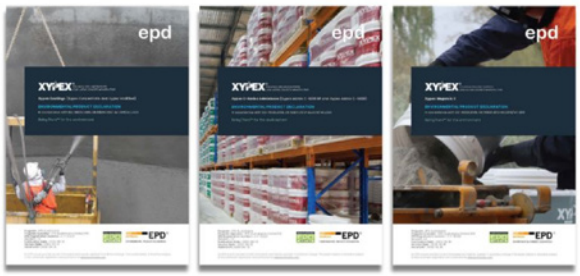
When dosing VpCI-649, users must decide how long they want corrosion protection to last, and then adjust concentration and dwell time accordingly.

The options range from protecting the metal during hydrotesting to protecting the metal for up to two years after hydrotesting.

Cortec has also developed the EcoEmitter, which is an engineered device to protect assets such as electronic and optical equipment and components from corrosion. The EcoEmitter can protect volumes up to 0 8.8ft^3, with the vapor phase corrosion inhibitors emitting from the device.

It then saturates the enclosure through diffusion, filling all void spaces and recessed areas with protective vapor molecules.

Countless applications around the globe have received the benefits of hydrotesting with VpCI-649.



Xypex Australia's Next Step Towards Sustainability

Xypex Australia recently announced the release of the latest Environmental Product Declarations (EPDs).

The EPDs are another significant step in Xypex Australia's venture into the sustainability space. Each EPD is independently verified and contains registered documents that communicate the environmental performance of a selection of products.

There are three EPDs, including:

- Xypex C-Series Admixtures (Xypex Admix C-1000 NF and Xypex Admix C-5000)
- Xypex Coatings (Xypex Concentrate and Xypex Modified)
- Xypex Megamix II.

Xypex Australia's commitment to the environment is enshrined in their commitment to zero carbon emissions.

As part of their ongoing testing and research, Xypex Australia has developed certified products that meet ecological requirements. The products have received Global GreenTag's CarbonRATE Certification, which means clients can rest assured knowing they are making sustainable choices.

Xypex Australia is committed to making a difference in the construction industry. The company provides tailored solutions to clients, which unlocks the potential for sustainable solutions for their projects. The company—operating in Australia since 1991—focuses on delivering watertight, durable and service life solutions to concrete structures.

Testing and research remain a key area for Xypex Australia's products and services. For example, the company has been involved in over 150 independent test reports surrounding the Xypex Modified Concrete, which has been exposed to a range of tough conditions in laboratory and on-site environments.

The company remains proud of their shift towards sustainable solutions and empowering the construction industry to make better choices.

The EPD's are available on Xypex Australia's website: https://www.xypex.com.au/news/item/176-epds.

Long-Lasting Protection for An Australian-First Bushfire Education Hub

Keeping the community safe during bushfire season is heroic work. In light of this, a purpose-built facility is addressing community resilience and recovery from a bushfire.

The Karla Katitjin Bushfire Centre for Excellence is a state-of-the-art education hub, which recently opened in the Peel Business Park, Western Australia.

The Nyungar names Karla, meaning fire, and Katitjin, meaning knowledge, were given by the Bindjareb community.

The Centre is a collaborative hub for bushfire personnel to research, learn and train in new methods of bushfire management.

WA Business Development Executive Nathan Hines was engaged to protect all structural steel, on both the interior and exterior of the facility.

"It was a case of true collaboration as we partnered with the project's multiple stakeholders including architects SITE Architecture Studio, applicators MBlast, fabricators Hot Weld Fabrication and builders Perkins Builders."

"When it came to product selection and application, the team at MBlast had a tried and tested system in mind to support the high volume, quick throughput of steel," Hines said.

Dulux Protective Coatings provided a three-coat system to maintain the durability of the facility, to ensure it will protect Perth and the wider Australian community for many years to come:

- Primer: Dulux Zincanode 402 at 75-microns (µm)
- Dulux Duremax GPE at 200-microns (µm)
- Dulux Weathermax HBR at 100-microns (µm).

Along with their fast and efficient application, all three products were selected as they provide long-term protection and an extended maintenance cycle.

The opening of the facility is expected to bridge the gaps in bushfire management throughout Australia.

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Electrochemistry, Corrosion and Data Analytics: A Pathway to Education and Better Asset Integrity

G. Will[1], S. Denman[2], M. Rahman[2], J. Davies[3]*

1 School of Science, Technology and Engineering, University of the Sunshine Coast QLD 4556, Australia
2 The Signal Processing, Artificial Intelligence and Vision Technologies (SAIVT) Research Group, School of Electrical Engineering and Robotics, Queensland University of Technology (QUT), QLD 4001, Australia
3 School of Mechanical, Medical and Process Engineering, Queensland University of Technology, QLD 4001, Australia *Corresponding author email: gwill@usc.edu.au

Keywords:

- Corrosion
- Data analytics
- Management
- Materials

Abstract:

The significance of materials degradation rate and its ensuing repercussions has played a paramount role in human progress. As a result, corrosion has been studied for hundreds of years and with the evolution of technology an increased understanding of the mechanisms and development of new materials has occurred. A foundational understanding of the corrosion process and its effective management is essential for the successful utilization of materials and the application of corrosion prevention methods.

The type of material, its history, and the environment should be considered wholistically to predict the degradation mechanisms and rate. Electrochemistry has traditionally been a key to unlocking the mechanisms and rates of corrosion reactions and advances in electronics and data analysis can be used to improve accuracy and educate future generations. At the industrial scale corrosion of assets is often assessed via inspections relying on images and other tools to determine current state of the material. Consolidation of material performance for a particular asset into a model which can learn and provide clear advice to maintainers and asset owners would be of great benefit.

With increased data capabilities and analysis techniques utilisation of a broader data set and diverse range of expertise is now becoming more available to those responsible for materials longevity.

Introduction

Percival Faraday Thompson (PFT), (1885-1951), was a metallurgist and analytical chemist who left a lasting imprint on much of modern science, philosophy and specifically the field of corrosion (Potter 1972). Identified as a corrosion pioneer in Australia and around the world, he had the great ability to work in many areas of science and like the great scientists had many insightful observations outside this realm. He was noted as great communicator and educator and it is this legacy we should embrace at every opportunity. He was not afraid to challenge and catalyse healthy debate around fair reaching topics many of which are preserved in his publications and subsequent reviews (Green 2015). These publications make for very entertaining and thought-provoking reading and some of these timeless learnings will be used to guide the following paper.

Briefly, PFT worked in a range of capacities as a chemist at the Working Men's College, Melbourne University, President of the Society of Chemical Industry of Victoria and the forerunners of both CSIRO and DSTG. As mentioned, many times it seemed destiny by virtue of his middle name, Faraday, that he would succeed in electrochemistry and corrosion with many notable scientific and industrial contributions in gold processing, lead, lubrication, aluminium, cost of corrosion, flow assisted corrosion, microbiological corrosion (MIC) and stress corrosion cracking were made. What prompts reflection from these papers were the incites and challenges he posed to the community at large that still resonate in our current day. The importance of learning from the past was an area PFT wrote about and a specific example being his history of analytical chemistry. He stood on the shoulders of those before him, doing so in a way which was thought provoking and entertaining. He was notably fond of rigorous productive debate and demonstrations and saw the value in groups like the Australasian Corrosion Association (ACA).

PFT was an educator with far reaching impact and vison, utilising "Corrosion Charts" which indicated areas of stability of a metal as a function of electrochemical potential which put him in line early on with the likes of Pourbaix. Also of note was his scepticism for standards and automatic analysis where he wrote "standard methods indicate a loss of that independence of thought which should be the most sacred possession" (Thompson 1932). Standards have their place to provide a basis of quality or practice but should not be a substitute for knowledge and stifle curiosity. He expressed his thoughts on the lack of chemistry knowledge in the engineering sector, yet the use of materials which undergo chemical degradation is a primary focus of their work. This is still a common sentiment but difficult to address with the extremely large breadth of competing knowledge required by engineers.

More broadly he wrote, "Around no subject of technical interest have prejudice and wrong thinking in the past, so wrapped a web of obscurity as that of the corrosion of materials". Even in current day, myths exist around the use of corrosion prevention techniques under given conditions that cannot be supported by the available science or industry experience. This has been reflected in a 2005 ACA conference paper "Junk Science in Corrosion Control: Gimmicks Gadgets and Gizmos" by the late Mark S. Schilling. (Shilling 2005) and should be the responsibility of corrosion professionals to increase awareness and focus on proven corrosion prevention techniques. PFT was clearly a man of great talent and insight with a generosity for educating and a thirst for knowledge who the great Edmund Potter commented "both international acclaim and conscious retirement eludes PFT, and he enjoyed no more than a languid waning of technical toil". (Potter 1972)

Discussion

Based on the legacy that PFT has provided the basic electrochemistry surrounding iron will be examined and how modern data analysis and modelling can provide both better interpretation of data and increase the education of electrochemistry and the corrosion process. This work is an extension of a previous PFT lecturer Paul Schweinsberg in conjunction with Harvey Flitt (Schweinsberg 2005) where polarisation curves are deconvoluted into the individual reactions extracting kinetic, thermodynamic

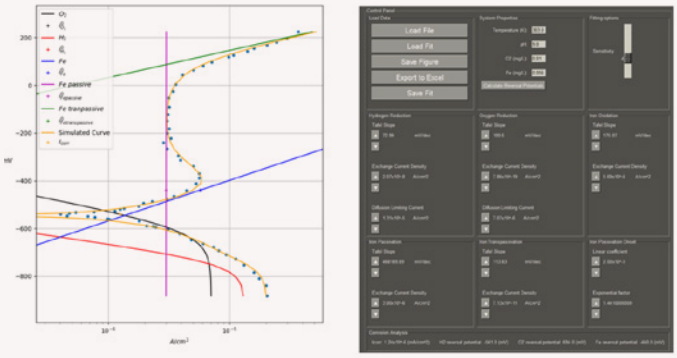

Figure 1: *Modern Symadec showing a polarisation curve for iron in an environment which promotes passivation. Dots are the experimental data; yellow curve is the fit to the data and other curves are the individual reactions and processes indicated.*

and cell characteristics. Figure 1 below shows the experimental data (dots) and the model fit to the data depicting the energetics (voltage) and kinetics (current) for each individual reaction occurring at the electrode surface. Modern computing and the accessibility to advanced modelling techniques has resulted in more advanced solutions which can not only supply better and more insightful results but educate users in the chemical reactions behind a specific system. PFT indicated the importance of educating and understanding the corrosion process

Material	Energy (MJ/kg)	Water (L/kg)	GHG emissions (kg CO2e/kg)
Stainless steel	97.6	140	7.2
Steel pipe	42.9	78	3.5
Concrete 32 MPa	1.1	1.8	.18

Table 1: *Embodied energy, water and emissions for common building materials. (http://epicdatabase.com.au/)*

and this can be accomplished by experimenting with the cell parameters to achieve changes in the theoretical curve and the goodness of fit.

Although increased knowledge of electrochemistry and corrosion science will assist in the better preservation of assets, in the field the non-ideal and time-based behaviour needs to be considered. Effective asset management is a major contributor to a sustainable future and this idea is often not articulated in discussions of renewable energy and carbon footprints. Conserving assets is something that the corrosion community has been doing for many years and now with the increase in the use of Life Cycle Assessments (LCA) this will become more transparent. (Atkins 2021) The embodied energy in popular construction materials gives one a scale for energy and equivalent CO_2 in modern structures which would be lost if not cared for properly, Table 1.

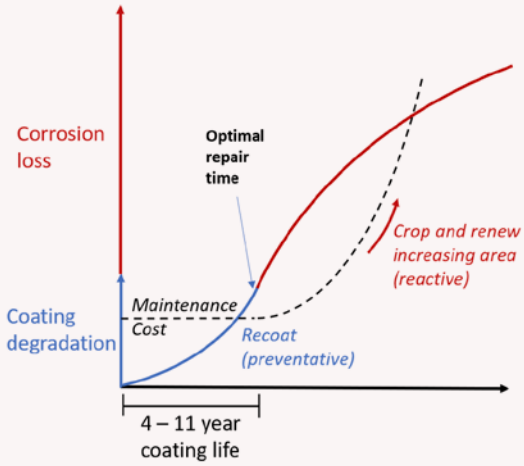

Figure 2: *Coating degradation and corrosion loss as a function of time for a typical engineering asset.*

The definition of corrosion refers to the degradation of all materials and much of our industry employs polymers as protective coatings. Protective coatings often define a structures life or at least its time to first or significant maintenance, Figure 2.

It is clear from this discussion that many factors and data streams are required to determine the current and future state of an asset. This provides a challenge for data scientists and corrosion practitioner but also presents opportunities to explore the ideal format for asset reporting and evaluation. One could imagine data bases developed for a structure which include build

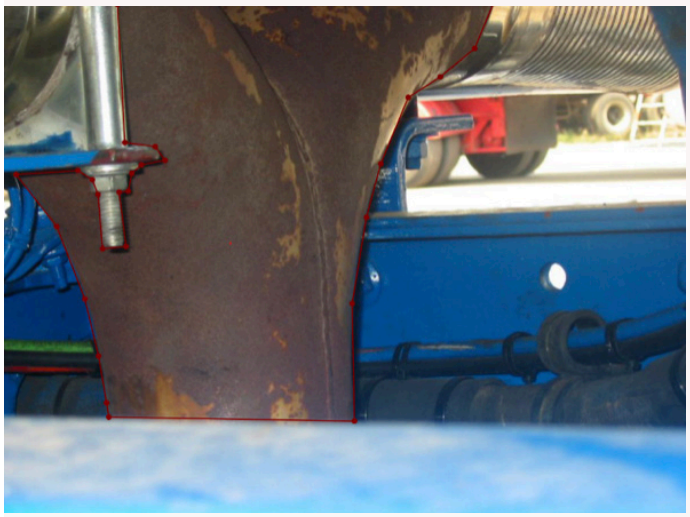

Figure 3: *Top: Training image part of a larger training set. This photo: Identified uniform corrosion using semanitic segmentation.*

information, geometries, QC reports, exposure conditions, inspection reports, repair data, financials, and availabilities along with the actual and modelled degradation rates of every point on the structure. Each piece of data provides different information in a variety of forms which all contribute to the managing an asset and are often lost or difficult to assimilate. The challenge presents opportunities to link data through various modelling methods to provide current state and future predictions of an asset ultimately populating a precision reality twin for visualisation and decision making.

Taking this one step further in the current age of artificial intelligence (AI) one could see the learning of previous assets informing both the manufacture and management of the future. Literature and standards currently are guides currently, but a supervised more integrated approach will assist decision makers to better outcomes. This is already being done with image analysis and autonomous inspections (eg. Abyss Solutions, Trendspek, SpotRust) (Nash 2022) where expert knowledge is used to continuously train and improve neural networks, Figure 3. The incorporation of expert knowledge is vital in guiding the AI, which can remove menial tasks, direct efficient inspection, and highlight difficult to identify features which can be used to augment decision making. AI needs to be trained and mentored by experts and the knowledge gained can be used to educate the next generations and provide a basis of future innovation. It is hoped that this would influence all stages of the asset's life informing initial design, fabrication, surface preparation, coating application, QC, coating failure and the onset identification and progress of degradation. Recently, physics informed AI is attempting to bring the underlying science and engineering models into training the neural networks, allowing smaller training sets to generate accurate results and predict future state (Zhu 2023).

With advances in drone technology and lidar scanning one can envisage autonomous inspection of assets particularly for confined space and hazardous areas which provide accurate area, volume and displacement changes associated with environmental and mechanical degradation. The results can used to make decisions but also after validation be included as training for the next iteration of the model such that continuous improvements are made.

Conclusions

The prevention of corrosion can benefit from the available data to understand, mitigate, and evaluate its progress. The collection, analysis, modelling and prediction capabilities available for these large data sets allows us to learn more about corrosion management, highlight short comings at the point of design and understand the implications of decisions on the overall life of an asset.

These are exciting times whereby the expertise of current and past practitioners and assets can be used to educate the workforce and manage materials

systems in the complexed world of corrosion more efficiently. The fear of technology is an age-old concern but as with previous advances, AI will used as a tool to educate, facilitate decision making, improve efficiency and augment current capabilities.

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MR. JOSEPH DAVIES specialises in corrosion management and analysis. Take a holistic approach to corrosion prevention that incorporates testing and monitoring of structural components so that important assets can be managed more optimally. My doctoral research pursues a better understanding of the degradation of organic coatings for corrosion prevention using inspection records, enhanced laboratory testing and in field condition monitoring.

ASSOC. PROF. GEOFFREY WILL has been a member of the ACA for over 22 years. Previously working at Queensland University of Technology for 23 years he has recently taken a position at the University of The Sunshine Coast. He has co-authored 177 papers in materials, electrochemistry, and molten salt corrosion. He serves on ASTM standards committee and consults to industry. His group developed techniques to monitor coating breakdown and models to predict corrosion behaviour. In the last 10 years his efforts supported high temperature solar thermal implementation.

DR SIMON DENMAN is a Senior Lecturer in the School of Electrical Engineering and Robotics at Queensland University of Technology (QUT). Simon actively researches in the fields of computer vision and machine learning, including action and event recognition, trajectory prediction, video analytics, biometrics, and medical signal processing. Simon has published over 140 papers in the areas of computer vision and machine learning, and co-leads the Applied Data Science research programme within the QUT Centre for Data Science.

DR MOHAMMAD MAHFUJUR RAHMAN is a Research Fellow in Signal Processing, Artificial Intelligence and Vision Technologies (SAIVT) in the School of Electrical Engineering and Robotics at QUT. He received his PhD degree in computer vision and deep learning from QUT. Dr Mahfujur research is in the fields of computer vision and machine learning, transfer learning, domain adaptation, domain generalisation, object detection, classification and image segmentation. He aims to utilise AI to enable visual learning.

Laser Cladding ff Fe-Based Alloy E-Cladtm as Hard Chrome Replacement for Hydraulic Cylinders in Mining

C. Schulz[1], A. Roccisano[1,3], T. Schlaefer[2], A. Hatem[1,3], C. Hall[1]

1 University of South Australia, Mawson Lakes, ***2*** LaserBond Ltd., Cavan,
3 The Australian Research Council (ARC) Industrial Transformation Training Centre in Surface Engineering for Advanced Materials (SEAM), Mawson Lakes, Australia

Keywords:

wear, abrasion, electrochemical corrosion, hard chrome replacement, mining.

Abstract:

Laser cladding is a deposition welding process that can apply a defect-free layer of wear and corrosion resistant alloys onto a metallic substrate with final thicknesses ranging from 100 µm to several centimetres. In contrast to electroplated hard chrome, where the coating material is always chrome, laser cladding can utilize a wide range of metallic materials as protective coatings.

This poses the possibility to adapt the coating to the service environment, for instance to design an alloy with tailored wear and corrosion resistance. While this presents an opportunity, it also makes the selection of the right material - a durable but economic solution - somewhat harder. In this study, a cost-effective Fe-based hard alloy, E-Clad™, was tested against the CoCrMo-alloy Stellite® 21 and the martensitic stainless steel AISI 431. The coatings resistance to sliding wear in a pin-on-disk setup and corrosion susceptibility via potentiodynamic scans in a sodium chloride solution were investigated. The proposed hard chrome replacement materials were benchmarked against an established hard chrome alternative, HVOF WCCoCr, and two different hard chrome coatings. The novel Fe-based materials were able to combine good wear and corrosion resistance while being an economic choice of coating material for hydraulic cylinders in mining.

Introduction

Hydraulic cylinders are mechanical actuators capable of supplying high linear loads in a multitude of industrial applications. The main components of a hydraulic cylinder are the piston rod, connected to the piston, the barrel, seals and the hydraulic fluid. Hydraulic cylinders operate by supplying hydraulic fluid into the cylinder on one side of the piston at high pressure causing motion of the piston due to the pressure differential. Hydraulic cylinders are used wherever pushing and pulling is required including in heavy earthmoving equipment, cutting and forming presses, and as actuators in aircrafts.

Whilst hydraulic cylinders are inherently very robust, they can fail with the most common causes being abrasive wear, fatigue, friction and corrosion. The piston rod is most often subject to failure due to aggressive environmental conditions and high cyclic loads. The piston rod can be exposed to the service environment when extended, meaning it is exposed to dirt, dust and corrosive liquids. Dirt and dust particles act as abrasives and cause wear of the rod. In a corrosive environment, i.e. marine application, the rod will be exposed to corrosive seawater which can cause premature failure of the rod if it is not sufficiently resistant.

Hydraulic cylinders are frequently used in underground mines in Australian. In mines, a high concentration of hard dust particles are present which can be highly abrasive to the exposed piston rod. Additionally, in some underground mines the environmental conditions can be particularly severe and include 100% humidity, at 60°C and 25,000-60,000 ppm chlorides. Hydraulic cylinders exposed to these conditions, harsher than the salt spray test (ISO 9227), must be produced from materials able to withstand both abrasive and corrosive loads. Materials used for piston rods, however, are typically mild and low alloy steels, with more expensive materials such as corrosion resistant austenitic (AISI 304) and wear resistant martensitic (AISI 410) alloys used for special applications with high demands [1].

Another solution to improve corrosion and abrasion resistance of piston rods is to apply a surface coating. Electrolytic hard chrome (EHC) plating is a common process that electrolytically applies a layer of chrome to the surface of piston rods to improve the wear and corrosion properties. EHC coatings provide good resistance to abrasion, with hardness in the order of 800-1000 HV, and corrosion resistance in many environments. There are, however, inherent issues with EHC plating, such as the danger of hexavalent chromium to the environment and plating personnel, high energy requirements of electroplating and the requirement to treat toxic process waste [1]. Plating with hexavalent chrome is banned or heavily restricted in an increasing number of countries and regions in the world and whilst exemptions exist, these are increasingly more difficult to obtain [2].

Alternative processes for the application of wear and corrosion resistant coatings for hydraulic piston rods have been investigated in the past 20 or so years. Suitable surfacing processes include thermal spraying, especially High Velocity Oxygen Fuel spraying (HVOF), and deposition welding techniques, like plasma transferred arc welding (PTAW) and increasingly in recent years laser cladding.

In the present study a novel Fe-based material, applied using laser cladding, at different hardness levels is investigated for its suitability to replace hard chrome on rods for hydraulic cylinders in mining. This is compared to 2 electrolytic hard chrome coatings, a WC-reinforced HVOF coating and 2 common laser cladding materials.

2. EXPERIMENTAL DETAILS

2.1 Coating processes

2.1.1 Electrolytic hard chrome

Electrolytic hard chrome (EHC) plating is a coating process that applies a layer of chrome onto a metallic substrate, usually steel, through electroplating. The coating can be decorative or, when applied as a thicker layer (20-250 µm), functional, providing wear and corrosion resistance. To electrolytically hard chrome a part, after cleaning and pre-treatment, it is submersed into a chromium containing chemical bath where a cathodic current is applied to reduce the chromium ions to metallic chrome that is deposited onto the substrate in the form of a uniform coating.

Hexavalent chromium oxide, also known as Cr(VI) is the most common chromium salt utilised in electrolytic hard chrome plating, however, Cr(VI) is a known carcinogen that causes severe health effects including lung cancer. Whilst environmentally friendlier and less toxic trivalent Cr(III) chrome plating processes exist, they are typically only used for decorative purposes as the process is self-limiting with a slower deposition rate [3].Therefore, hard chrome plating is now heavily restricted in Europe and China as well as several industries like aviation and automotive [2]. More countries and industries are likely to follow suit in coming years.

The main attribute affecting corrosion resistance of hard chrome coatings is the density of micro-cracks (microribbons). Cracks form in EHC coatings due to residual stresses that form during the coating process. When the residual stress is relieved, the crack gets filled with material that contains a higher concentration of oxygen than chrome. Density of micro-ribbons depends on bath chemistry, current density and temperature during electroplating. The higher the density, the smaller the depth and widths of the micro-ribbons. Chromium protects by forming a resistant barrier. Therefore, coatings must be thicker than the crack depth to provide corrosion protection. [4]

2.1.2 Laser Cladding

Laser Cladding is, in essence, a build-up welding process in which a high-powered laser is used as a heat source to melt a powder feedstock onto a base material, forming a metallurgical bond between the two. A schematic diagram of the laser cladding process is provided in Figure 1. During operation, the laser is focussed on the surface of the part to be coated whereby a melt pool is formed as the top layer of the surface of the substrate is liquified to molten metal. The feedstock powder is injected into the focal point of the laser, where it is melted just before or inside the melt pool. This forms a molten mixture of feedstock powder and substrate. More feedstock powder is then melted on top of this layer mixture forming a homogeneous build-up of the feedstock material. As the layer cools, a smooth, thin transition between the base substrate and the coating is produced, forming a metallurgical bond between the coating and the substrate. By advancing the laser and powder nozzle, a continuous track of cladding can be applied to the substrate. By overlapping tracks, a uniform and thicker coating can be formed over large surface areas. In contrast to other welding techniques, such as GTAW or PTA welding, the dilution zone for laser clad coatings is very small, typically < 5% [5]. In comparison, the dilution observed in GTAW and PTA can be up to 50%, depending on the coating and substrate [6, 7]. In addition, the Heat Affected Zone (HAZ) and distortion of a laser clad workpiece is considerably smaller, almost negligible, compared to traditional welding processes [5].

Laser Cladding can be used for remanufacturing of worn parts, applying a wear and/or corrosion resistant coating to susceptible substrates and for additive manufacturing.

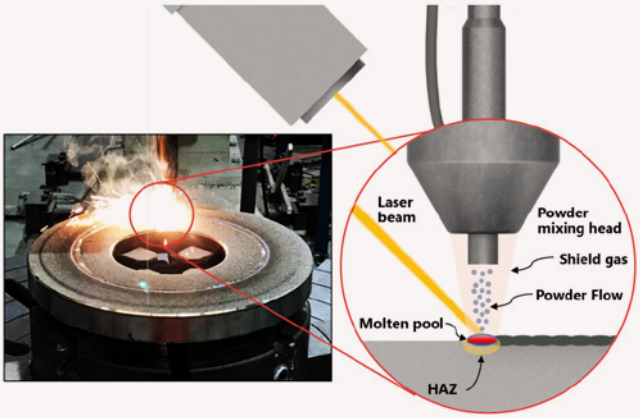

Figure 1. Laser Cladding, process schematic (right), process image (left).

2.1.3 Thermal Spraying

HVOF is a surface coating technology where a substrate is thermally sprayed with a performance-enhancing coating, as shown schematically in Figure 2. HVOF operates by injecting a powder feedstock into a high-pressure torch where it is accelerated up to 1,000 m/s, melting or partially melting due to the intense heat of the torch. The substrate is roughened prior to spraying to promote bonding of the coating to the substrate. This roughened surface provides an anchor point for the coating to adhere to. When the molten or semi-molten particle hits the substrate

the impact results in the molten metal flattening and cooling rapidly onto the surface of the substrate. As the molten metal cools, it contracts. This contraction can then grip onto rough surface asperities by compressing onto peaks and in troughs of the surface [8]. Thin layers are built up of these flattened particles. The size of these splats depends on the feedstock powder and the parameters of the gun. By adjusting these parameters and the powder, the coating can be optimised.

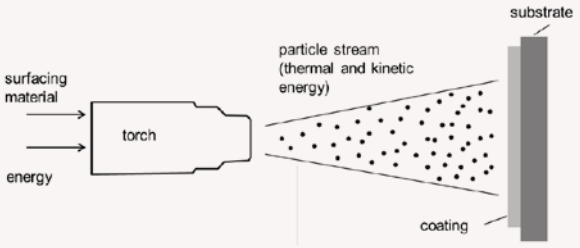

Figure 2. Thermal spray process.

2.2 Materials

In this study, a total of seven coatings were evaluated for their sliding wear and corrosion resistance. The deposition method and hardness of the evaluated coatings are listed, along with their average hardness and manufacturing process in Table 1. Two Fe-based hard alloys were investigated for their suitability as EHC replacements, E-Clad 50 and E-Clad 65, differentiated by their hardness. These two novel alloys were benchmarked against conventional hard chrome coatings as well as industrially accepted hard chrome replacements.

Two EHC coatings Hardchrome A and B were sourced from different suppliers. Despite providing identical specifications the two coatings were considerably different in terms of thickness, and, density and size of microribbons, as can be observed in Figure 3. Hardchrome A had a higher coating thickness than Hardchrome B, 220 µm vs 70 µm, wider and deeper microribbons and a lower hardness, 878 HV vs 985 HV; likely providing overall a lower resistance to wear and corrosion.

A HVOF WCCoCr coating served as another reference material. HVOF spraying of WCCoCr on hydraulic rods is a certified hard chrome alternative for landing gears on aircrafts [9]. The coating consists of 86 wt% of WC, 10 wt% Cr and 4 wt% Co. The high proportion of tungsten carbides makes this material the hardest in the present study at 1245 HV.

AISI 431 is a martensitic 17% Cr steel that combines moderate wear with moderate corrosion resistance. It is, therefore, regularly selected as a replacement for hard chrome in hydraulic rods. In laser clad form, it has a hardness of 510 HV. For environments where a high corrosion resistance is required, such as for hydraulic cylinders in marine applications, a more corrosion resistant material is typically selected. Cobalt based materials combine a high corrosion

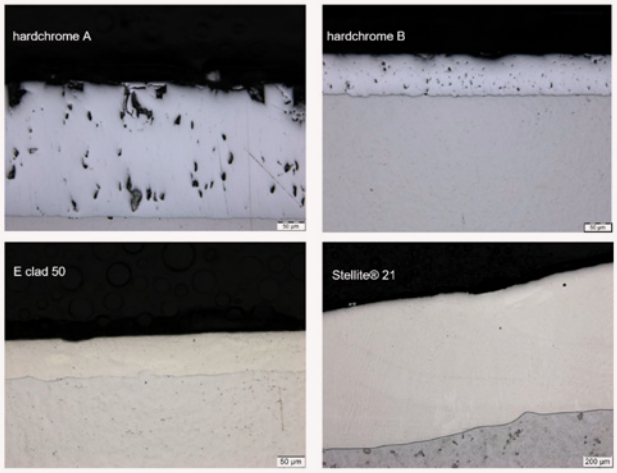

Figure 3. Optical micrographs of selected coatings.

Coating	Coating Process	Hardness [HV0.3]
Hardchrome A	Electrolytic hard chrome	878
Hardchrome B	Electrolytic hard chrome	985
WCCoCr	HVOF	1245
AISI 431	Laser cladding	510
Stellite® 21	Laser cladding	445
E-clad 65	Laser cladding	823
E-clad 50	Laser cladding	663

Table 1: Investigated coating materials, coating process and hardness

resistance with high wear resistance. In this study the alloy Stellite® 21, CoCr27Mo5, was investigated for its wear and corrosion resistance.

2.3 Wear testing

Wear testing was carried out on a pin-on-disk tribometer (Microtest S.A, Spain) per ASTM G99 shown schematically in Figure 4. Specimens were ground with successively finer grits and polished using diamond polishing compounds to a mirror finish. Samples were degreased with ethanol and affixed to a rotating holder. Samples were then rotated under dry contact conditions against a stationary, rigidly held 6 mm alumina ball (grade 20). Sliding wear was evaluated with a normal force of 10 N, a track diameter of 10 mm, relative velocity of 0.1 m/s for a total sliding distance of 1000 m. Each test was repeated a minimum of 3 times to ensure statistical significance with the resulting volume loss obtained by means of an Olympus LEXT OLS 5000 Laser Confocal Microscope. Wear resistance was assessed by evaluating the wear rate of the materials. Wear rate (K) was calculated using equation (1), with V, volume loss in mm3, s, wear distance in m, and F, normal load in N.

$$K = V/F\,m \qquad (1)$$

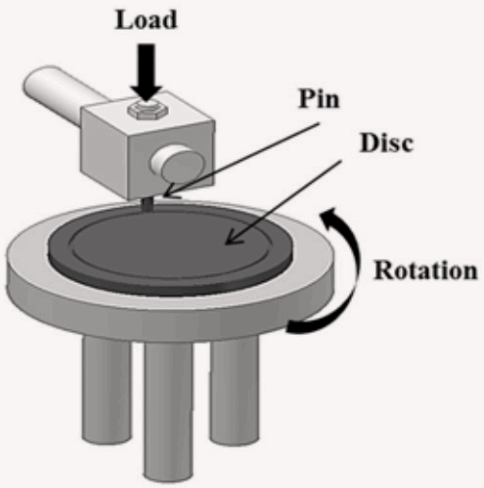

Figure 4. Schematic of pin-on-disk wear test.

2.4 Corrosion testing

2.4.1 Polarisation Test

Electrochemical corrosion tests were conducted in 3.5 wt.% NaCl solution at pH 7. The electrochemical measurements were conducted using a Pine Wavedriver potentiostat in a typical three-electrode configuration with a saturated calomel electrode as a reference electrode. Coatings were polished to a mirror finish prior to testing to ensure comparable surface topographies. Open circuit potential (OCP) was measured for 45 minutes to allow stabilisation of the system prior to potentiodynamic evaluation. Measurements were carried out in a naturally aerated, unstirred solution at room temperature with a scan rate of 0.25 mV/s.

2.4.2 Salt spray test

Salt spray testing was carried out in an Ascot S120i salt spray chamber per ASTM B117 or ISO 9227. To prevent corrosion of the substrate during testing, uncoated surfaces were painted with a corrosion resistant paint. Samples were continuously exposed to a fog of pH neutral 5 wt.% NaCl solution at 35°C. At set intervals, the materials were inspected, imaged and, in the event significant rust had formed, removed from the salt spray chamber.

3. RESULTS AND DISCUSSION

3.1 Wear testing

Pin-on-disc testing was undertaken to evaluate the sliding wear resistance of investigated materials. The average wear rate K of three pin-on-disc tests, evaluating the sliding wear is shown in Figure 5. Hardchrome B performs 3x better than the 107 HV softer Hardchrome A coating. Despite both hard chrome coatings being manufactured through the same process, differences in coating parameters can dramatically alter the material performance.

The lowest wear rate was observed in the HVOF WCCoCr. As this coating possessed not only the highest hardness but also 86wt% of highly wear resistance tungsten carbides, it is unsurprising that this Metal Matrix Composite (MMC) has by far the lowest volume loss. The Fe-based reference coating, AISI 431 had the highest wear rate of the investigated samples, slightly worse than Hardchrome A. The Stellite® 21 specimen

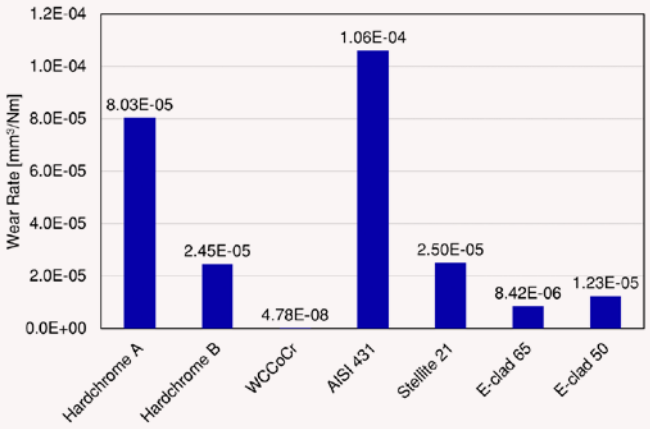

Figure 5. Pin-on-disk results.

The novel Fe-based hard chrome replacement specimens E-clad 65 and E-clad 50 both performed remarkably well, experiencing wear rates lower than Hardchrome B, the best performing hard chrome coating. Both examples performed approximately on par with each other with the higher hardness E-clad 65 experiencing marginally lower wear than E-clad 50. The excellent wear resistant properties of the experimental E-clad materials was due to finely dispersed hard phases in a Fe-based matrix. This gives the alloy a superior wear rate over the electrolytic hard chrome references, despite a lower hardness.

performed as well as Hardchrome B despite the significantly lower hardness. This was due to the low coefficient of friction of Stellite® 21 of 0.41 that allowed it to resist wear remarkably well despite its lesser mechanical properties. Coefficient of friction for all other materials was ranging between 0.65 and 0.81.

3.2 Corrosion testing

3.2.1 Polarisation Test

A comparison of the corrosion behaviour of typical hard chrome coatings and the hard chrome replacements in 3.5 wt.% NaCl is presented in Figure 6. Hydraulic rods in mining applications are commonly exposed to high chloride containing environments and the suitability of the proposed hard chrome replacements are benchmarked against the existing materials. As observed in the electrochemical polarisation curves in Figure 6 the two hard chrome coatings were the least noble/stable of the investigated materials in 3.5 wt.% NaCl solution. Despite being produced through the same process, Hardchrome A experienced at least a 10× greater corrosion velocity than Hardchrome B. The presence of wider and deeper microribbons in Hardchrome A as compared with Hardchrome B, visible in Figure 3, would account for the difference in corrosion rate. The presence of cracks in hard chrome coatings has been reported in the literature to increase the corrosion susceptibility [10].

Despite possessing the highest wear resistance, the WCCoCr HVOF coating possessed the lowest corrosion resistance of the investigated hard chrome replacement coatings. Whilst the HVOF WCCoCr possessed a nobler open circuit potential than either EHC coating, it had a significantly higher current density than any investigated sample.

The remaining four coatings had similar corrosion potentials Ecorr = 200 ±30 mV and current densities icorr, with Stellite® 21 and E-clad 50 displaying the noblest corrosion potentials. The main distinguishing feature of this group of materials was their pitting potential Epit, the point where the current density abruptly increases. Distinct pitting potentials were observed in E-clad 65 at 0 V, AISI431 at 220 mV and E-clad 50 at 280 mV. This feature was not present in the Stellite® 21 coating, indicating that in this chloride containing solution, Stellite® 21 will not pit. As Stellite® 21 contains a high proportion of cobalt and chromium, it is unsurprising that it exhibited the best corrosion properties.

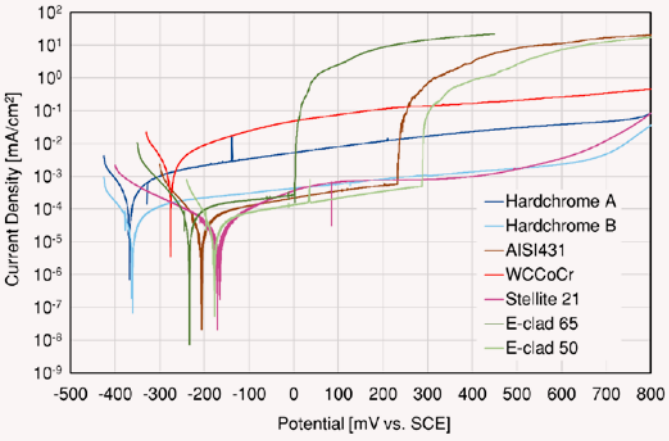

Figure 6. Electrochemical polarisation curves in 3.5 wt% NaCl solution at pH7, scan rate 0.25 mV/s.

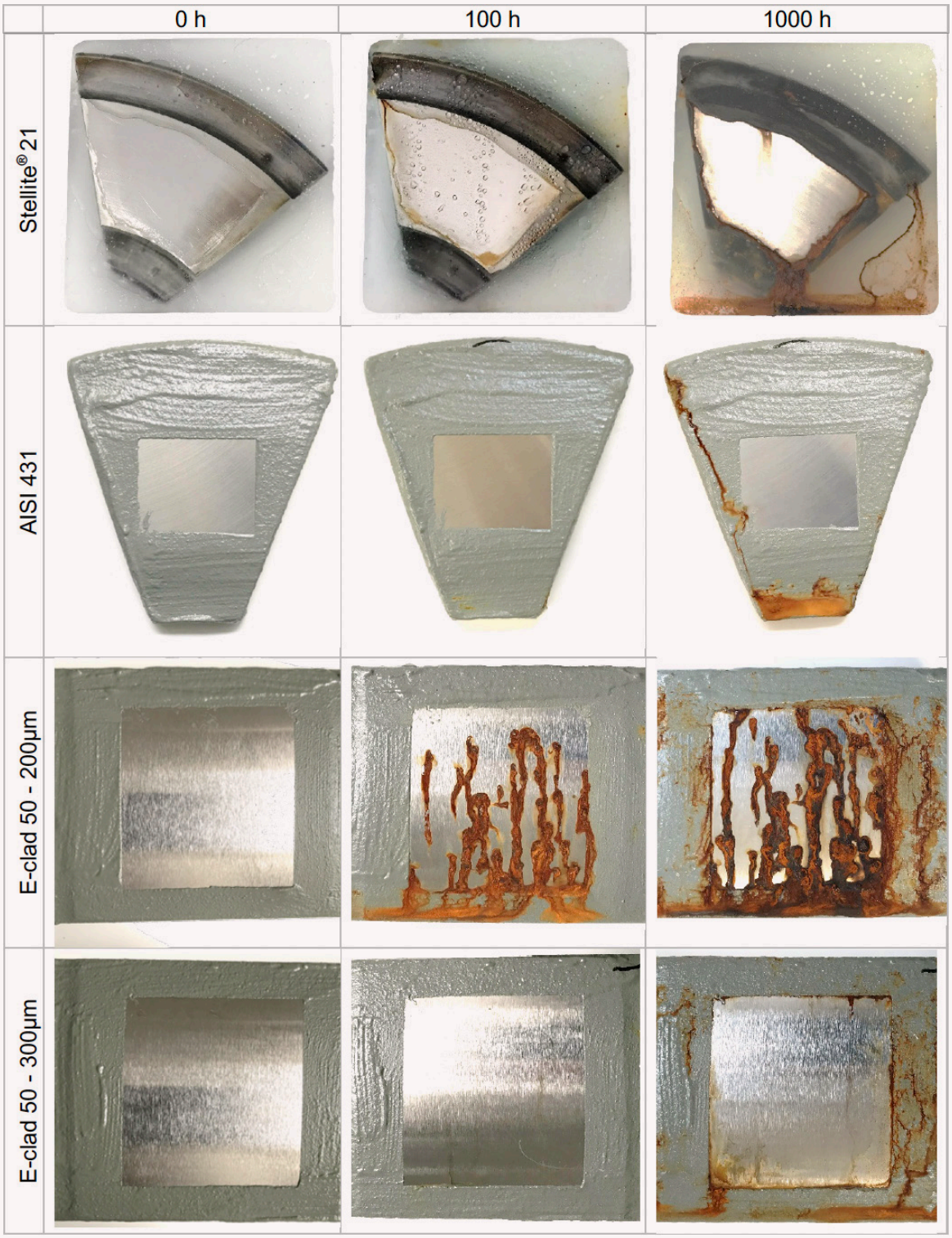

Figure 7. Selected materials after exposure to salt spray. The experimental E-clad coating was tested at different thicknesses, 200 µm and 300 µm. The 200 µm coating showed pitting corrosion after 100 h of exposure, whereas the 50% thicker coating of the same material did not show any signs of pitting corrosion after 1000 h. This demonstrates the importance of coating thickness on the capability of a coating to serve as a protective barrier. An inadequate coating thickness can lead to rapid degradation and thus catastrophic coating failure. It is important to find the right balance between minimum coating thickness for sufficient corrosion protection and economic considerations for material costs and processing time.

3.2.2 Salt Spray test

The results before, after 100 hours and after 1000 hours in the salt spray for Stellite® 21, AISI 431 and E-clad 50 at 200 and 300 µm coating thickness are presented in Figure 7. Stellite 21, AISI 431 and the thicker E-clad 50 coating do not corrode until the end of the test at 1000 hours. The visible red rust on these samples is from the mild steel substrate, where the organic coating has failed.

4. CONCLUSIONS

When evaluating the performance of hard chrome alternatives for hydraulic piston rods, it was determined that in terms of sliding wear (pin-on-disk), the experimental Fe-base materials E-clad 50 and E-clad 65 performed better than commercial laser clad coatings made of the martensitic steel AISI 431 and Stellite® 21, as well as two electrolytic hardchrome coatings, Hardchrome A & B. With respect to corrosion, E-clad 50 had a higher pitting potential Epit than AISI 431, therefore outperforming the martensitic steel. The E-clad 50 a higher pitting potential than AISI 431 and overall had the 2nd lowest corrosion potential. Stellite® 21, overall, had the best sliding wear and corrosion resistance. This is due to the low coefficient of friction in sliding wear, and high stability of Co in chloride-containing solution and lack of defined pitting potential.

In summary, both E-clad materials are suitable as hard chrome replacement in terms of their sliding wear resistance. In a service environment with high corrosive load, especially a chloride-containing environment, Eclad 50 outperforms AISI 431 and hardchrome coatings but doesn't reach the outstanding resistance of Stellite® 21. To determine the best coating for a particular service environment of hydraulic rods consideration should be given to the complex of loads the coating will experience of lifetime.

5. ACKNOWLEDGMENTS

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7. AUTHOR DETAILS

Dr.-Ing. Christiane Schulz is a surface engineer with a focus on solving industry problems. She has 10 years of hands-on experience in the coating processes laser cladding and thermals spraying which are used to apply thick metallic and cermet coatings. Her research interest is wear and corrosion resistant coatings in heavy industries like mining, energy, steel, agriculture and offshore.

Anthony Roccisano is a postdoctoral researcher with a keen interest in manufacturing R&D. His research interests include materials science and metallurgy, particularly process improvement and microstructural characterisation.

Andre Hatem is a Ph.D. candidate of the Australian Research Council training centre in Surface Engineering for Advanced Materials (SEAM). His project focus on the additive manufacturing of steel structures on existing base bodies or entire components via Laser Metal Deposition.

Thomas Schlaefer is a process & materials expert who leads LaserBond's R&D department. He achieved his Doctorate in mechanical engineering at the Surface Engineering Institute of RWTH Aachen University, Germany, which is one of the leading research institutes for coating materials and processes in Europe. He has extensive experience and knowledge of materials and coating processes, and technical skills related to Laser Cladding, Thermal Spraying, application-oriented coatings development, materials development, and materials and composites analysis.

Colin Hall is an Industry Associate Professor at the Future Industries Institute (University of South Australia). Colin is interested in helping manufacturing through the uptake of innovative research based around coating technologies. Colin has worked in private industry for 9 years and academia for 15 years giving him a unique perspective for industry engaged research. Colin completed his PhD in material science in 2014.

A Novel Aspect in Monitoring Waterline Corrosion, its Inhibition, and the Influencing Factors

Waterline corrosion is a major localised corrosion concern for metallic infrastructures that are partially exposed to an electrolytic solution and air, leading to an established separation of anodic and cathodic areas. This type of corrosion is common in marine steel piles and piers, offshore wind turbines, shore-crossing steel pipelines, drilling rigs, oil platforms, bridges, on the internal surfaces of liquid nuclear waste tanks and on pipelines that are used to store and transport aqueous corrosive liquids. Waterline corrosion is difficult to assess, detect and control mainly because of the limitations in conducting experiments capable of monitoring the localised phenomena occurring at anodic and cathodic sites. Therefore, there is insufficient understanding of key factors affecting waterline corrosion and very few inhibitors have been reported for limiting its damage. In this work, an electrochemical technique (based on Wire Beam Electrode (WBE)) was used as a new approach to study waterline corrosion and to understand the key contributing factors to waterline corrosion behaviour, as well as to explore the effectiveness of environmentally friendly corrosion inhibitors for waterline corrosion.

The WBE employed in this work consists of 100 square electrodes of the same size (arranged in 25*4), which are coupled together to simulate a continuous metal coupon (Figure 1a). This design not only allows the continuous monitoring of corrosion over the whole electrode surface during a long exposure time, but also allows local polarisation curve measurements at specific locations of interest [1]. The results obtained so far have shown that rust deposits play a significant role in waterline corrosion behaviour, both in neutral and alkaline environments [2]. Rust layer formation on the steel surface was found to initiate a second corrosion mechanism, i.e., crevice corrosion facilitated by the rust layers, in addition to galvanic corrosion facilitated by the oxygen differential aeration cell. Local polarisation curve measurements showed significant changes in polarisation behaviour and there were changes in local anodic current at anodic sites before and after removing rust from their surfaces (Figure 1e-g) [2]. Recent results of local polarisation curve measurements showed that five days after adding lanthanum hydroxy cinnamate, it acts as an anodic inhibitor at anodic areas and as a cathodic inhibitor at cathodic areas in pre-corroded steel samples partially immersed in neutral electrolyte. Future work will investigate the use of a mix of inhibitors for preventing localised corrosion, by using our understanding of the key factors affecting waterline corrosion.

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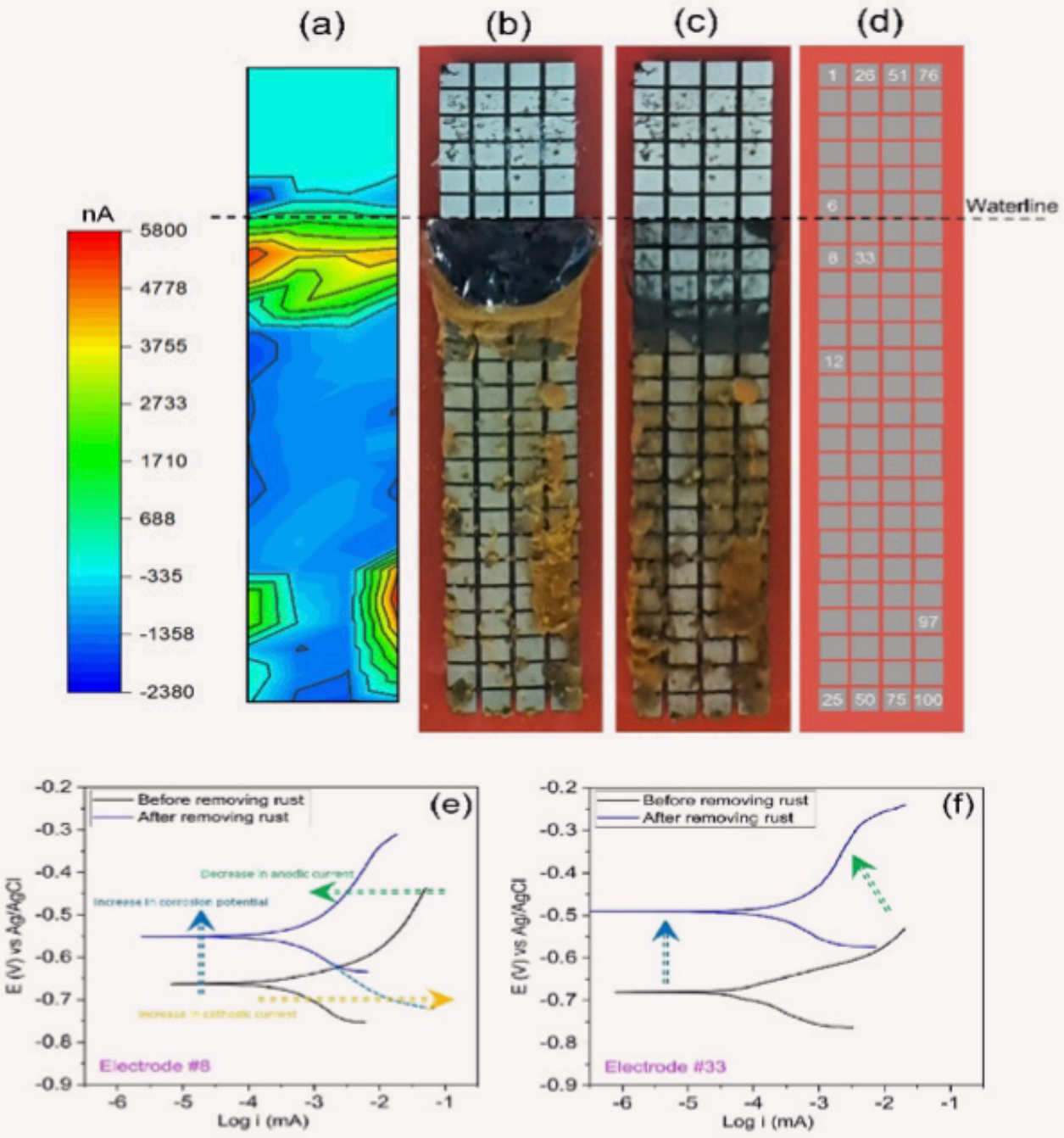

Figure 1. Galvanic current map distribution along with its colour bar from the WBE partially immersed in an alkaline environment for 14 days, showing the presence of prime anodes just below the waterline. Negative and positive currents represent cathodic and anodic sites, respectively. (b) Photograph of the WBE at day 14 of immersion, indicating an extensive rust formation at the waterline area. (c) Photograph of the WBE after manually removing rust at the waterline area. (d) Schematic image of the WBE indicating the location of the electrodes that were chose for local polarisation curve measurements. Local polarisation curves at anodes where (e,f) rust was removed and (g) rust was not removed.

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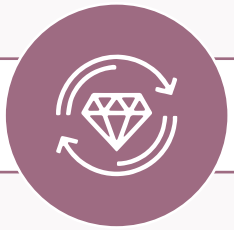

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