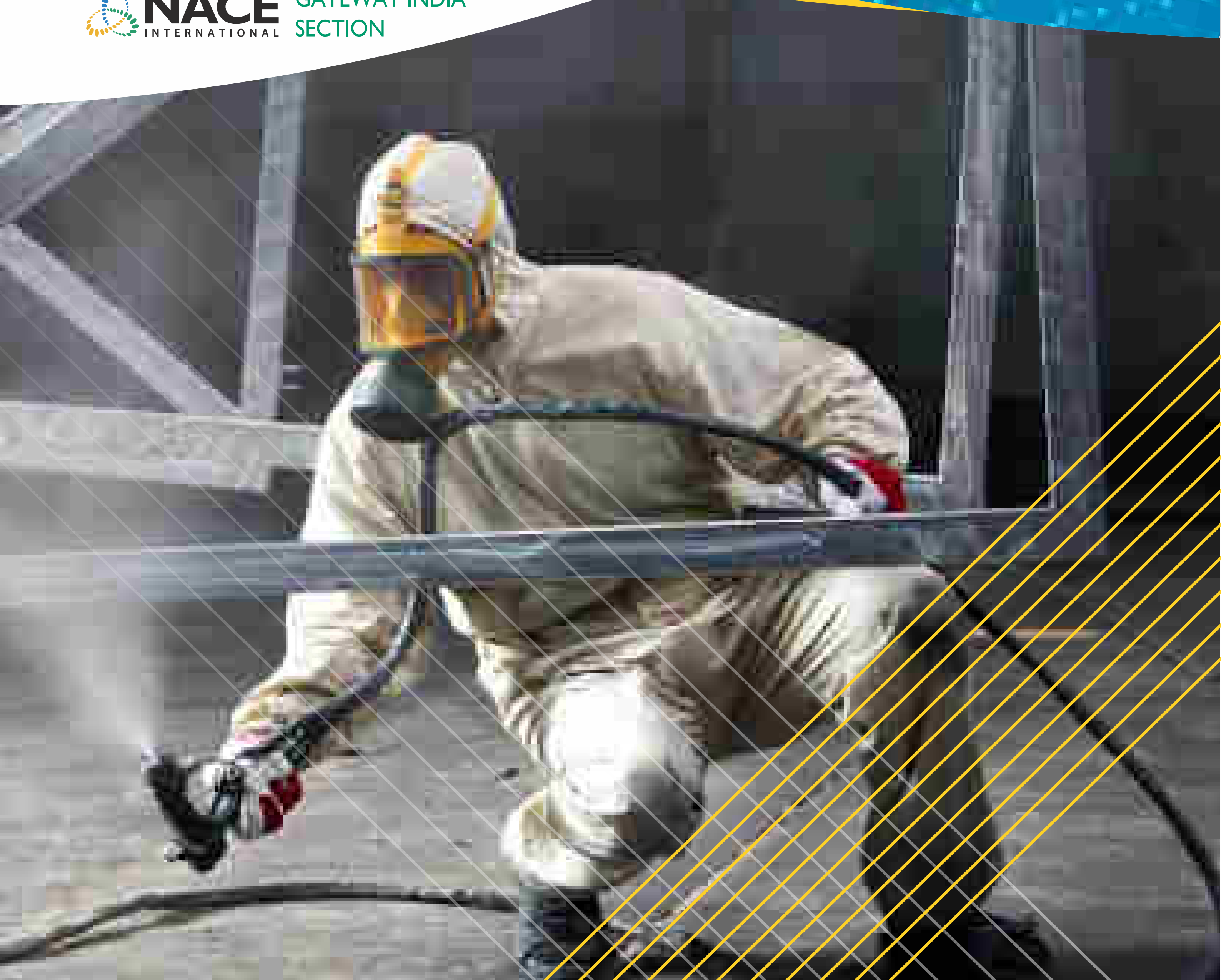
CORROSION COMBAT

Quarterly Newsletter of

NACE INTERNATIONAL GATEWAY INDIA SECTION



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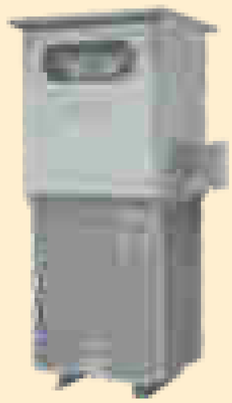

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Corrosion Combat design & layout compiled by Rishikesh Mishra, Manager-Technical Services, NIGIS.

Letters to the editor are always welcome. We invite your suggestions, comments and views on the Newsletter as well as articles for publications. To publish your article, submit it to rishikesh@naceindia.org

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Editorial

Dear friends and colleagues,

Best wishes of the new year 2020. We are happy to bring out the first issue of the year for the newsletter Corrosion Combat. In this issue, we bring you discussions on various important aspects of corrosion. The corrosion control and monitoring in the pipelines are important due to its large economic and strategic importance. Cathodic protection is the major corrosion combat method for the pipelines. Accurately designing the cathodic protection systems requires precise prediction of the current and potential distribution over the structure to be protected. The issue elaborately discussed various theoretical and modelling approaches adopted to address the issue. The stress corrosion cracking (SCC) is the most critical corrosion problem in many applications, but the form of corrosion is very dangerous and costly in nuclear applications of high strategic value. Understanding the mechanism of the SCC requires the interrelation between the nature of the steel, its thermos-mechanical history, the environment of exposure and the presence of certain species such as chloride ions, etc. The dependence on the multiple parameters makes the mechanistic understanding of the SCC complex. The electrodeposition is one of the oldest methods of creation of the surface coatings. The beauty of the method is the accurate control of the deposition kinetics and selectivity through the precise control of the current and the potential. The method has the capability to create multilayer coatings with out-of-plane composition and functionality variation. However, extensive research is needed for the commercial implementation of the electrodeposition of complex coatings on large areas. The issue also bears its usual features, reports on the various events and short term courses organized by the NACE. The notable is the CORCON 2019 International Conference & Expo on corrosion conducted very successfully from 23 – 26 September, 2019 at CIDCO Convention Centre, Mumbai. In this new year, the newsletter will try to bring out new features for all its readers in the industry, academia, and students.

Dr. S. Parida
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Electrodeposition: A simple technique to develop corrosion resistant coatings

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Indian Institute of Technology Hyderabad, Telangana,
National Institute of Technology Karnataka, Mangalore

Abstract

Electroplating is an extremely important technology, which involves covering inexpensive and widely available base materials with plated layers of different metals/alloys having superior properties to extend their use to applications which otherwise would be prohibitively expensive. The electrodeposited coatings can be denser, harder, more corrosion resistant, more protective of the underlying base metal, tougher and stronger, more wear resistant, superior with respect to magnetic properties, more suitable for subsequent electroplate overlays and conversion chemical treatment, superior in antifriction applications etc. Electrode position has been emerged as a versatile and convenient route over the last decade for the synthesis of a variety of nano materials like nano crystalline deposits, nano wires, nano tubes, nano multi layers and nano composites. The modern methods of electrode position such as composition modulated multilayer alloy (CMMA) deposition and magneto electrode position (MED) can ensure the development of coatings with significant enhancement in materials properties compared with the conventional ones. The article discusses the importance of conventional and modern electrode position techniques to develop corrosion resistant coatings.

Introduction

Surface finishing is a promising engineering technique to enhance the surface properties of a solid matter by applying a thin complementary layer on the surface of the bulk material. Such finishing treatment can ensure enhancement in material properties like durability, decorative appeal, electrical conductivity, chemical resistance, tarnish resistance etc. Though many surface finishing technologies are available, electroplating has been evolved as a promising technology over recent decades due to its development from an art to an exact science. The wide acceptability of electroplating in practical science and engineering is evident from the ever-increasing number of publications in this field. Electro plating or electrochemical deposition deals with the synthesis of thin solid films from dissolved simple salts by alteration of their oxidation states accomplished using external power source. In other words, it can be defined as the process of depositing the metal/alloy onto the surface of a substrate by electrochemical reduction of metal ions by passing direct current (DC) through their electrolyte solution. The advantages such as low cost, formation of thicker deposit, convenience in depositing on complex shapes, easiness in controlling and modifying the deposit character etc., making it more attractive. A number of key industries like automobile (which uses for example chrome plating to enhance the corrosion resistance of metal parts), electronics, tooling etc. adopt electroplating, even where other methods, such as evaporation, sputtering, chemical vapor deposition (CVD), physical vapor deposition (PVD) etc. are available, due to genuine reasons of economy, accuracy, reproducibility and convenience involved in the process. Due to rapid progress in the field of electroplating, in terms of new advanced methods of deposition like composite electrode position, magneto electrode position, so no electrode position etc., electroplating has been emerged as one of the leading-edge technologies today.

Practical electrode position

Electrode position is one of the most attractive methods for the synthesis of new materials with tailor-made properties on a wide range of base metals. Though it is very simple to execute with low cost, the process of electrode position is very complex due to the unusually large number of critical elementary steps and operating parameters which control the overall process. The main factors which can influence the process of plating are:

i) metal salt and electrolyte concentration,
ii) deposition current density,
iii) temperature,
iv) agitation,
v) polarization,
vi) pH of the electrolytic bath,
vii) substrate effects and viii) nature of anode.

A large number of variables apart from these can also affect the structure and properties of deposits. However, the above mentioned are of greater significance in electroplating process.

The electrode position of metal coatings is usually based on aqueous electrolytes, known as electrode position baths or simply, baths. Their primary constituents are metal salts of the metal to be deposited; in most cases, they are either acidic or alkaline to promote conduction, and in some cases, it is buffered. In order to optimize the deposit properties, a small amount of additives, or complexing agents are used. Many electrolytes used in metal finishing are based on complexes. The metal deposition is brought about either by current flow from an external power source, or by the addition of strong reducing agents, which set up a coupled anodic and cathodic reaction. Depending on which is the case, the terms 'electrode position' and 'electro less deposition' are used. In both the cases, the composition and operating parameters of the bath are crucial in attaining a good quality deposit.

Generally, a practicable method for the electrode position of any metal/alloy involves three steps; preparation of the surface to be plated, optimization of the plating bath and finally deposition from the proposed bath. In this, the most important step is concerned with the development of a suitable plating bath. This requires a practical knowledge of the electrochemistry of elements, the solubility of their salts, and the chemistry of their complexes. However, due to lack of some quantitative guiding principles, the electro platers are required to rely on some semi-empirical procedures upon which generalizations and theories can be built. In this regard, the Hull cell experiment is widely used as a practical tool for plating bath optimization. Hull cell, named after its inventor Richard Hull, has been brought into practice in the electroplating industry as early as 1939. The Hull cell is a miniature plating unit designed to produce cathode deposits on a panel that correlates the characteristics of the plating bath being evaluated.

Modern methods of electrode position

Electrode position is a well-known coating technique to tune the shape of microcrystals, control their growth and their composition for developing metal/alloy/composite coatings with tailor-made properties. A common method to manipulate the deposit property is by introducing a suitable additive into the plating bath, which can preferentially adsorb on specific crystallographic planes and alter the growth mechanism. Apart from that, by bringing variations on the mass transfer process during deposition can also offer coatings with enhanced material characteristics. In this regards, the development of multilayer coatings and magneto electrode position are considered as promising methods to synthesize new materials with advanced properties. The development of such new materials is driven by the fundamental principles such as: i) periodic modulation in mass transport process at cathode brings a periodic modulation in composition of the deposited coatings, according to the basic principle of electrode position, ii) the material property of the coatings towards corrosion resistance and electrocatalytic activity can be increased substantially by increasing the surface area of the coatings, according to the basis of nano technology (the increase in surface area can be achieved either through layering or by composite electrode position), iii) the enhanced mass transport at the electrode/electrolyte interface can result in the formation of coatings with high reluctant metal content than in conventional methods. Keeping in view of the above points, the development of composition modulated multilayer alloy (CMMA) coatings and magneto electro deposited (MED) alloy coatings can ensure significant enhancement in materials properties towards corrosion protection compared with the conventional coatings.

Composition modulated multilayer alloy coating

Today, in search of efficient surface coating materials for better corrosion protection, the focus has been given for development of compositionally nano-modulated multilayer, or simply nano laminated alloy coatings in place of their conventional monolayer (monolithic, or homogeneous) coatings. These coatings are popularly called as CMMA coatings, consisting of a sequence of two metals/alloys, alternately deposited one above the other, as shown in Fig. 1. They are developed by pulsing periodically the current/voltage during deposition. The nano laminated alloy coating technique is gaining interest amongst the researchers due to genuine reasons of low cost and greater flexibility to tailor the properties, like thickness of the coating and ability to control the texture and interfaces. Generally, nanolaminated multilayer alloy coatings developed electrochemically exhibit better electrical, magnetic, optical, chemical and mechanical properties quite distinct from their monolayer (monolithic/bulk/non-nanostructured) alloy counterpart . Even though

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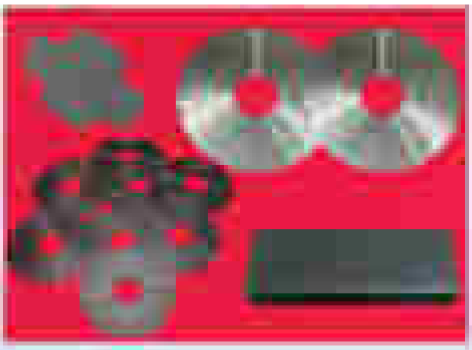



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techniques such as evaporation, molecular beam epitaxy (MBE) and sputtering are some of the common methods still in use for development of multilayer coatings, their high cost and practical difficulties made the multilayer coatings by electrolytic process more popular . The CMMA coating technology has grown in the past decades as a promising and exciting extension to the range of surface coatings and associated applications.

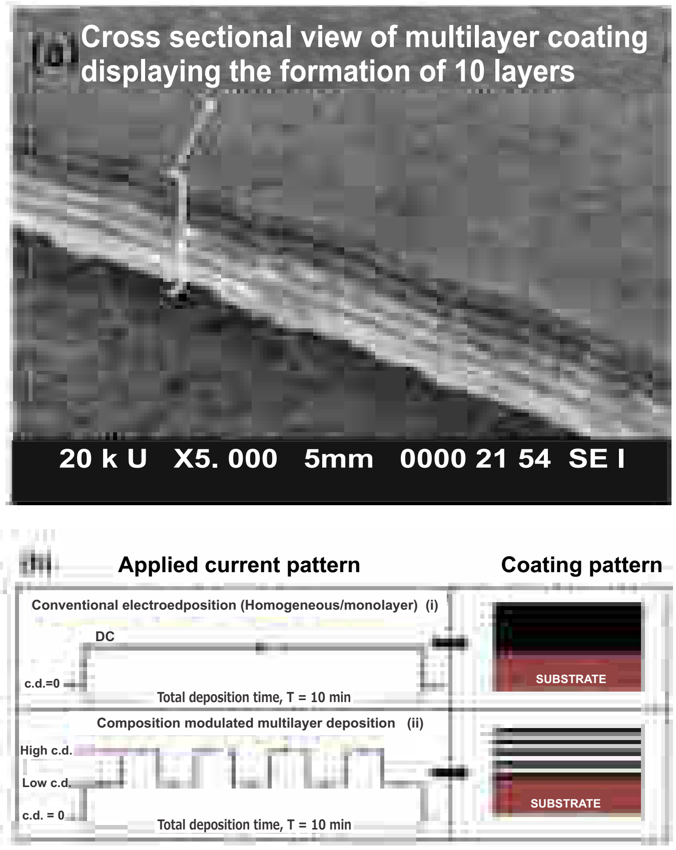


Fig. 1- a) SEM image of a CMMA coating of Ni-W alloy, and b) schematic of power patterns used for the deposition (left) of Ni-W alloy, and the corresponding coatings developed (right): i) monolayer, and ii) multilayer

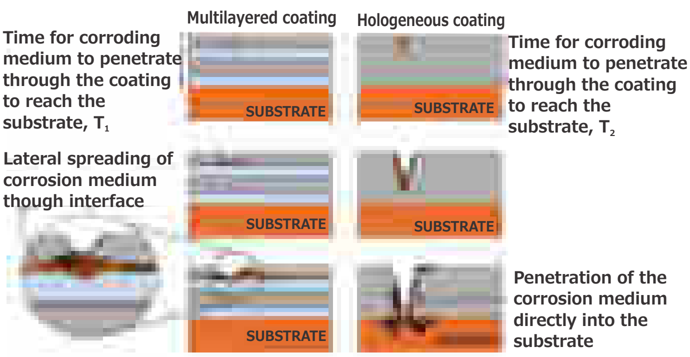
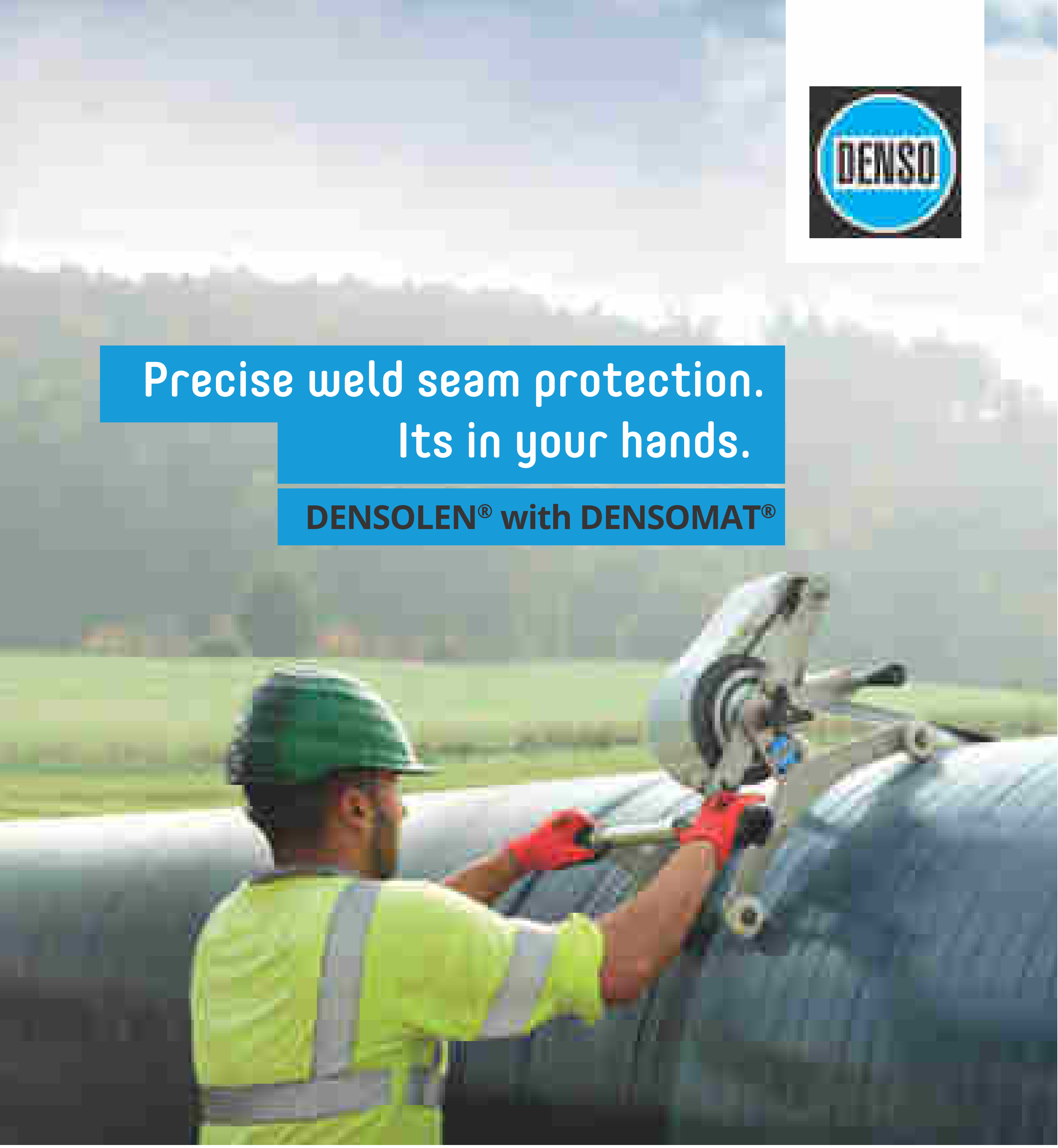


Fig. 2- Diagram showing the mechanism for increased corrosion protection of multilayered coating (left), compared to the monolayer or homogeneous coating (right), deposited from the same bath for same duration. It demonstrates that the time required for the corroding medium to reach the substrate by penetrating through the multilayered coating (T_1) is much greater than that through the monolayer coating (T_2) due to increase in the number of interfaces, formed due to layering, compared to its monolayer coating.

In CMMA coatings, each individual layers have a distinctive role and a suitable combination of coating parameters can be used to enhance the final product performance without increasing the total coating thickness. The composition and thickness of each individual layer can be manipulated to optimize the desired property of the multilayered coating . The betterment in the properties of multilayer coatings lies in the control of mutual diffusion of the neighbouring layers after deposition. However, it is also possible to vary the deposition condition to produce a predetermined compositional gradient in the as-deposited condition. These film materials may possess unusual, but novel properties, making them very important from a practical standpoint. Due to the increased effect of surface, or interface arising from the exceptional thinness of the individual layers of the CMMA coatings, it can exhibit large deviations from bulk behavior, which raises the total properties of the composition modulated multilayers (CMMs) compared to their monolayer counterparts [19,24]. Since the layering is achieved at near atomic dimensions, the developed nanostructured multilayer alloy coatings attain remarkable and sometimes unique properties which are not attainable in normal metallurgical alloys . The CMMA coatings show significant improvement in corrosion resistance and their corrosion protection mechanism is illustrated in Fig. 2.

Magneto electrolysis

Magneto electrolysis, or simply magnetolysis works by employing magnetic induction and electrolysis together: two basic concepts applied in a new way. The superimposition of magnetic field (B) in an electrochemical processes can have large practical significanc . The topic is inherently interdisciplinary, including the concepts of electrochemistry, hydrodynamics and magnetism. The results are sometimes surprising, and their elucidation can lead to unexpected insights into fundamental electrochemical processes, as well as new practical applications. Basically, magnetolysis covers four major aspects of electric/magnetic field interactions. They are: i) magnetic field effect on electrolyte properties, called magnetohydrodynamic (MHD) effect, ii) electrolytic mass transport, iii) to a smaller extent on electrode kinetics and iv) nature of electrodeposit.



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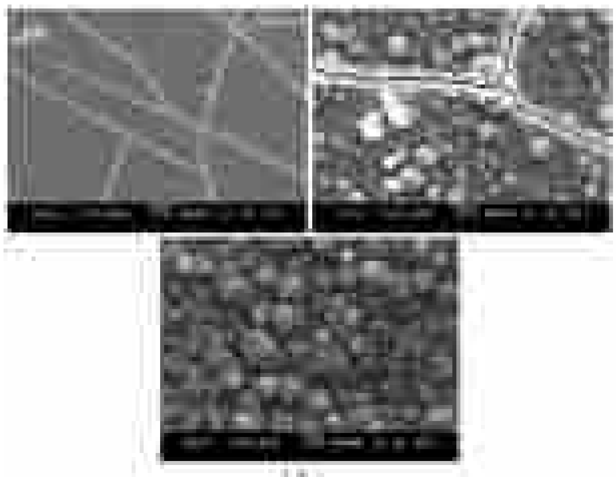
The MHD effect, arises mainly due to Lorentz force (force acting on charged ions moving in an electromagnetic field) is responsible for the effects of B on electrochemical processes .

Effect of magnetic field on electrodeposition

The B induced during electrodeposition can change flow patterns, increase in the intensity of mixing, increase in the rate of deposition, and hence, can modify the structure and morphology of deposit. During Magnetoelectrodeposition (MED), the enhanced convection and the strong push for deposition can be explained using the MHD effect, interacting with the structure of the convective diffusion layer at the electrode. It is reported that the superimposition of B during electrodeposition has great influence on the deposit characteristics like nucleation, growth, texture, phase composition, macro-stresses, hardness, morphology, current efficiency, preferred orientation etc. The MHD effect, arises mainly due to Lorentz force can enhance the mass transport at the electrode/electrolyte interface during deposition and can impart better coating properties . MED can ensure a more uniform current distribution, leading to a more uniform deposited layer with change in the crystallization behavior. Apart from that, MED can enhance the corrosion resistance and electrocatalytic activity of the deposits. The extent of effect due to superimposition of B during MED on coating characteristics depends on the intensity and direction (parallel or perpendicular) of the applied magnetic field . The variation in morphology and corrosion resistance of Ni-W alloy coatings developed using conventional and MED (under different conditions of applied magnetic field in terms of both direction and intensity of B) methods are shown in Fig. 3, as an example. Here, the applied B was used as a tool to alter the crystallinity, composition and thereby the corrosion resistance of the coatings. Nowadays, MED has attained more attention towards the effect on induced codeposition of the reluctant metals (elements which cannot be deposited alone from aqueous solutions) like, molybdenum, tungsten, phosphorus, boron etc., in the presence of inducing metals (Fe, Co, Ni etc.). A number of investigators have reported the significant effect of the applied magnetic field on various aqueous electrolytic processes .



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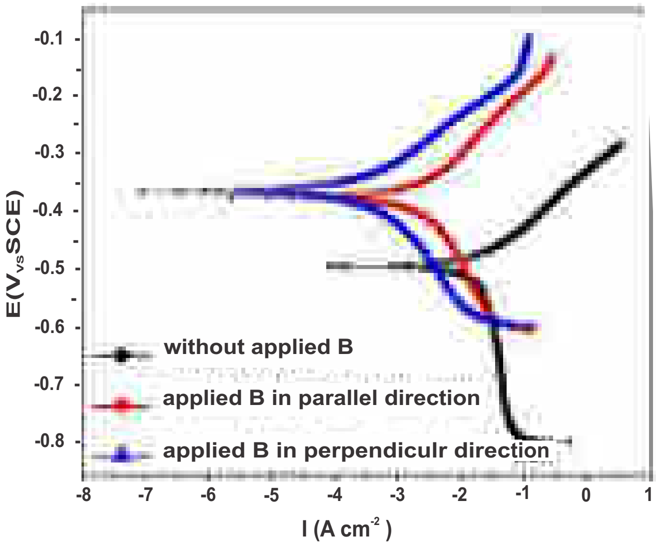

(B)

Fig. 3- A)SEM images of the conventional Ni-W alloy coating in comparison with MED coatings (all deposited from the same bath at same current density) under applied magnetic field in parallel and perpendicular direction: a) without applied B, b) applied B in parallel direction, and c) applied B in perpendicular direction, and B) Comparison of corrosion behaviors of the conventional and MED Ni-W alloy coatings developed for the protection of mild steel substrates, measured through potentiodynamic polarization method.

Conclusions

Electrodeposition can be effectively used for the development of a vast number of metal/alloy/ composite coatings, having concomitant practical applications, in a cost-effective route. The corrosion resistance of electrodeposited coatings can be increased substantially by tailoring the composition, phase structure and morphology, by controlling the deposition current density. Periodic modulation in mass transport process at cathode brings a periodic

modulation in composition of the coatings. Therefore, many properties including corrosion resistance of monolayer alloy coatings can be increased to several folds by multilayer coating approach. Superimposition of a magnetic field during deposition can offer better material properties to coatings, especially in terms of corrosion resistance. The applied magnetic field can be used as a tool to alter the crystallinity, composition and thereby the corrosion resistance of the coatings.

References

1 A. Brenner, Electrodeposition of alloys: principles and practice, Academic Press, USA (1963).

2 N. Kanani, Electroplating: basic principles, processes and practice, Elsevier, USA (2004).

3 L. Elias, A.C. Hegde, Journal of Materials Engineering and Performance. 27 (2018) 1033–1039.

4 L. Elias, A.C. Hegde, Electrochimica Acta. 219 (2016) 377–385

5 L. Elias, A.C. Hegde, RSC Advances. 6 (2016) 66204–66214.

6 L. Elias, A.C. Hegde, Journal of Alloys and Compounds. 712 (2017) 618–626.

7 L. Elias, P. Cao, A.C. Hegde, RSC Advances. 6 (2016) 111358–111365.

8 A.R. Shetty, A.C. Hegde, Surface and Coatings Technology.322 (2017) 99–107.

9 W. Schwarzacher, Electrochemical Society Interface. 15 (2006) 32–33.

10 J.K. Luo, M. Pritschow, A.J. Flewitt, S.M. Spearing, N.A. Fleck, W.I. Milne, Journal of the Electrochemical Society. 153 (2006) D155– D161.

11 N. Parthasaradhy, Practical Electroplating Handbook, Prentice-Hall, USA (1989).

12 J. Dini, Electrodeposition: The Materials Science of Coatings and Substrates, Noyes Publications, New Jersey (1993).

13 F. Lima, U. Mescheder, H. Reinecke, Solar Cells. 6 (2012) 7.

14 L. Elias and A. C. Hegde, Journal for Electrochemistry and Plating Technology.(2016).10.12850/ISSN2196-0267. JEPT5393.

15 L. Elias, A.C. Hegde, Analytical & Bioanalytical Electrochemistry. 8 (2016) 629–643.

16 D.M.A. NabiRahni, P.T. Tang, P. Leisner, Nanotechnology. 7 (1996) 134.

17 S. Roy, Electrochemical Fabrication of Nanostructured, Compositionally Modulated Metal Multilayers (CMMMs), In Electrochemistry at the Nanoscale, Springer, New York, (2009) 349–376.

18 L. Elias, A.C. Hegde, Surface and Coatings Technology.283 (2015) 61–69.

19 L. Elias, K.U. Bhat, A.C. Hegde, RSC Advances. 6 (2016) 34005–34013.

20 D. Tench, J. White, Metallurgical Transactions A. 15 (1984) 2039–2040.

21 H. Idrissi, J.P. Millet, S. Audisio, A. Irhzo, Journal of Materials Science. 29 (1994) 5327–5332.

22 V.A. Zabludovsky, E.F. Shtapenko, Transactions of the IMF. 75 (1997) 203–204.

23 S. Rashmi, L. Elias, A.C. Hegde, Engineering Science and Technology, an International Journal. 20 (2017) 1227–1232.

24 P. Leisner, C.B. Nielsen, P.T. Tang, T.C. Dörge, P. Møller, Journal of Materials Processing Technology. 58 (1996) 39–44.

25 T.Z. Fahidy, ElectrochimicaActa. 18 (1973) 607–614.

26 U.E. Steiner, T. Ulrich, Chemical Reviews. 89 (1989) 51–147.

27 L.M. Monzon, J.M.D. Coey, Electrochemistry Communications. 42 (2014) 38–41.

28 L. Elias, A.C. Hegde, Electrocatalysis. 8 (2017) 375–382.

29 J.A. Koza, I. Mogi, K. Tschulik, M. Uhlemann, C. Mickel, A. Gebert, L. Schultz, Electrochimica Acta. 55 (2010) 6533–6541.

30 V. Ganesh, D. Vijayaraghavan, V. Lakshminarayanan, Applied Surface Science. 240 (2005) 286–295.

31 M. Waskaas, Y.I. Kharkats, The Journal of Physical Chemistry B. 103 (1999) 4876–4883.

32 M.-Y. Lin, L.-W.Hourng, C.-W.Kuo, International Journal of Hydrogen Energy. 37 (2012) 1311–1320.

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CORCON 2019: International Conference & Expo 23 - 26 September 2019, Mumbai.

CORCON 2019, the largest event related to corrosion mitigation in Asia, was a grand success with active participation from academic and research institutions, public and private sector organizations including defense establishments and professionals. It was held at the sprawling CIDCO Convention Centre, Navi Mumbai, September 23 – 26, 2019, the 26th Annual Corrosion Conference and Expo (CORCON 2019) was organized by NACE International Gateway India Section (NIGIS), one of the largest and most active sections of NACE International.

Dr U. Kamachi Mudali, Chairman, CORCON 2019 said "CORCON 2019 is a technical feast for the delegates numbering over 900 from industry, academia and R & D all across the globe, with four plenary talks, 24 keynote lectures, 175+ technical talks distributed across 36 sessions and over 25 technical poster presentations; this, besides the seven technical interactive forums along with a round table conference on the 'Protective Coating Industry". "Corrosion is not new to all of us; we live with corrosion," said Dr Mudali, who is also the Chairman and Chief Executive, Heavy Water Board, Department of Atomic Energy, Government of India. "If you look at the geographical location, out of 257 countries India stands 17th in the world for its length of over 7,500km of coastline. Corrosion is a menace in such a coastal and marine environment."

"In the pipeline sector, we have roughly 18,000km of natural gas pipelines cross crossing the country. The Government of India will be investing an additional Rs 70,000cr to augment this sector. The Indian Oil Corporation Ltd, has 14,000km of pipelines for crude oil distribution and they have plans to increase this to 20,000km soon. All of us know that pipelines are prone to corrosion depending on various factors involved." Dr Mudali also noted that the paints and coatings sector worldwide with a market of US$160bn would grow to US$208 by 2022, which is around a growth rate of 5.4 percent yearly, which is a good figure. Besides, there are a lot of innovations like self-healing coatings, self-regenerating coatings, intelligent coatings, and all these are coming in a big way and CORCON would be a place to learn about these.

The inaugural function on September 23, 2019 had Dr V. P. Joy, IAS, Director General, Directorate General of Hydrocarbons, Government of India as Chief Guest. He spoke about how our country will become the key driver of global energy demand in the next twenty-five years. "Our energy consumption of more than 1.2 billion population will grow by 4.2 percent a year for the next twenty-five years, which is fastest among major world economies," he said, emphasizing on the importance of corrosion prevention and mitigation in the hydrocarbon sector.

He said, he was happy to see lots of fruitful papers and ideas being presented during the conference which would definitely help in improving activity in one's domain of work. "Corrosion is multi-disciplinary and is a critical aspect in any economy. In the area in which I am concerned, like the energy sector, corrosion is a very big priority. In the energy production, transmission, utilization there are large structures involved. Then, we have large lengths of pipelines running across the country and all these are subject to environmental influence and affected by corrosion. So, in short, when we are discussing about corrosion, we are discussing about a very important aspect of the economy.

Mr B. Narayan, Group President, Reliance Industries Ltd., Guest of Honor at CORCON 2019 said: "The CORCON series of conferences and exhibitions have played an important platform for the industry, research organizations and academics to exchange information on the new experiences in the field of corrosion, ongoing development work in protection or mitigation of corrosion and new techniques being successfully employed in measurement, control and automation in the corroion field."

Other dignitaries who spoke included Mr Jeff Didas, NACE Immediate Past President; Mr Robert H. Chalker, Chief Executive Officer, NACE International; Mr Toyoji Takeuchi, East Asia and Pacific Area Director, NACE International; Mr Tushar Jhaveri, Past President, NACE International, and Mr N Manohar Rao, Trustee, NIGIS .

Interesting 'Technical Interactive Forums (TIF)' like the one on 'Delivering Performance Through Optimum Coating Specifications' explored the scope of coatings specifications and how it plays a very critical role in the design life of an asset. The one on 'Regulations and Standards in Corrosion' discussed the need for standards in the field of corrosion and its control in industry and to what extent the need is being met by organizations formulating standards including NACE International and the Bureau of Indian Standards. The TIF on 'Corrosion in Concrete' discussed the challenges associated with poor quality construction materials / methods, poor workmanship, lack of awareness of latest technology, lack of corrosion management policies and mindset etc. The topics of the other TIFs included 'Water Treatment,' 'Corrosion Monitoring and Testing,' and 'Corrosion Control in City Gas Distribution.'

'Jung se Jung,' – Battle against Corrosion – another popular program at CORCON is intended to integrate the theoretical findings with the actual experience of the eminent people in the subject field. The topics discussed included internal corrosion, the MIC phenomenon, AC interference corrosion, inspection of non-piggable pipelines and corrosion mitigation.

The Round Table Conference on Protective Coating Industry convened by Mr S. Ravichandran, Berger Paints India Ltd., discussed topics like Training and Industry Connect Programs; Painter Qualification and Coating Contractor Certification; the NACE Impact Study; the Coating Inspectors Training Program of NACE; and NIGIS' Corrosion Consultancy Programs.

Technical papers distributed across 35 sessions were presented under various channels such as Cathodic and Anodic Protection; Coatings, Linings and Thermal Insulation; Materials and Composites; Bio materials Corrosion; Corrosion Monitoring and Testing; Corrosion Control in Water Treatment Utilities; Corrosion in Automobiles and transportation industry, Corrosion in Oil and Gas Industries; Corrosion in Petrochemical and Refinery Industries; Internal Corrosion in Pipelines; Corrosion in Power Plants and Utilities; Corrosion in Chemical and Fertilizer Industries; Corrosion in RCC Structures; Microbial Corrosion and Inhibitors; Marine Corrosion; Corrosion in Defense Equipment and Facilities; and Direct Methodology Applications. To encourage students there was a Young Student Scientists Forum and over 25 interesting and educative poster presentations.

The conference is also used as a platform to honor and respect individuals and institutions for their contribution to corrosion awareness and developments in the field of corrosion science and technology in India. The awards were presented during a function on the second day of the event.

This year, the Excellence in Corrosion Science and Technology in Research and Education was awarded to Dr Radhakrishna G. Pillai, IIT Madras, Chennai; the Excellence in Corrosion Science and Technology in Oil and Gas was given to Mr Basanta Kumar Lenka, Technimont Pvt Ltd., Mumbai; Excellence in Corrosion Science and Technology in Quality Management and Control, Dr Anil Krishna Kar; Distinction in Corrosion Science and Technology in Research and Education, Dr S. C. Vanitha kumari, Indira Gandhi Centre for Atomic Research, Kalpakkam, Distinction in Corrosion Science and Technology and Industry, Mr Viswanathan Venkateswaran, Petronas Chemicals Methanol SDN, Malaysia; Student Award for PhD Degree, Dr M. Ajay Krishnan, IIT Bombay, Mumbai; and Dr Poulami Chakraborty, Homi Bhabha Research Institute, Mumbai; Student Award for M. Tech, Mr Madhura B., Indira Gandhi Centre for Atomic Research, Kalpakkam; Award for Excellent Laboratory, Corrosion Laboratories at IIT Madras, Chennai; Meritorious Contribution in Research and Education, Mr T. Subba Rao, Bhabha Atomic Research Centre, Kalpakkam; Meritorious Contribution in Industry, Mr Sandeep Harshadray Vyas, Reliance Industries Ltd, Navi Mumbai; and the Lifetime Achievement Award, Prof Gurmeet Singh, Pondicherry University, Pondicherry.

CORCON 2019 was not only about heavy corrosion mitigation stuff, but also had its share of fun and mirth. The Cultural Program, organized on the evening of the third day of the event had Ms Ketaki Samarth and her troupe enthralling the audience with their rendering of Kathak dances. The program began with a Ganesh Vandana and followed by a few pure dance pieces like the 'todas' and 'tukdas,' followed by the depiction of different aspects of Lord Ganesha using fusion music and western beats.

This was followed by a unique interactive drumming experience by Drum Café, wherein the entire audience was given a drum each and led by Dr Vinod Hasal, through motions of communal drumming which lightened up the environment, broke down barriers, inspired people and took the entire audience across different rhythmic motions. Drum Café was actually started as a Café where drumming was used in a relaxed environment to break down barriers, inspire and bring people together.

CORCON 2019 also boasted of a large exhibition area where 81 stalls from not only India but across the globe used the opportunity to introduce their products, technology, and services to the industry.

This year, CORCON 2019 was also supported by the Ministry of Steel, Government of India; Ministry of Chemicals and Fertilizers, Government of India; Federation of Indian Chambers of Commerce and Industry (FICCI); Federation of Indian Petroleum Industry (FIPI); and the City and Industrial Development Corporation (CIDCO), Government of Maharashtra.

19 best symposia awards and 5 best poster papers, as chosen by eminent experts, were presented during the valedictory session. Awards for two best exhibition stalls and two runner-up exhibition stalls were chosen among the 81 exhibition stalls, were also presented.

Glimpses of CORCON 2019

Dr. U. Kamachi Mudali, Chairman, CORCON 2019 warmly welcoming the fellow delegates

Dr V. P. Joy, IAS, Director General, Directorate General of Hydrocarbons Government of India as Chief Guest during Lamp Lighting Ceremony

Dignitaries on the Dias releasing the CORCON 2019 Souvenir

Dr. Homero Castaneda delivering the Plenary address

Dr. U. Kamachi Mudali facilitating Dr. Abdullah Moghram Al-Ghamdi during his Plenary talk

Interaction with Exhibitors in the exhibition stall

Best Technical Paper Awards

1 Bio-materials Corrosion : Fluoride conversion coating: A solution for effective control of corrosion rate and enhanced bio-adaptability for orthopaedics K. Saranya and N. Rajendran , Anna University, Chennai

2 Cathodic and Anodic Protection : HVDC Interference on MGL Steel Pipeline Network Shraddha Garate, Mahanagar Gas Limited, Mumbai

3 Coatings, Linings and Thermal Insulation: Thermal Spraying of Polymers on Metals: A New Development Satish Tailor, Ankur Modi, S. C. Modi, Metallizing Equipment Company Private Limited, Jodhpur

4 Corrosion Control in Water Treatment Utilities : Case Study on Addressing Corrosion issues in Raw Water Treatment due to usage of Ferric Chloride as coagulant Venkata Sai Rambabu, Shivakumar, ONGC Mangalore Petrochemicals Limited, Mangalore

5 Corrosion in Automobiles and transportation industry : Prediction of Cumulative Galvanic Corrosion Damage under Service Life Environmental Conditions Robert Adey, Andres Peratta, John Baynham, Tim Froome, CM BEASY Ltd, UK and Thomas Curtin Computational Mechanics International Inc., Billerica, MA

6 Corrosion in Chemical and Fertilizer Industries : Experience Sharing On Corrosion & Its Mitigation In H2S Based Heavy Water Plants Roma Goel, S. R. Gaidhani, K. V. Tale, M. Yaseen, R. K. Gupta, Heavy Water Plant, Kota

7 Corrosion in Defence Equipment & Facilities Nano titania based hydrophilic self-cleaning high solid coating for ship`s superstructure R. Baloji Naik, R S Naik, N G Malvankar, Sushil S. Pawar, T. K. Mahato, NMRL, Ambernath

8 Corrosion in Oil and Gas : Advanced Water Wetting Model for Pipelines T. Bos, Shell Technology Centre Bangalore, Y. Zheng, Shell Technology Centre Houston and J. Sonke, Shell Technology Centre Amsterdam

9 Corrosion in RCC Structures : Effect of ultraviolet exposure on corrosion performance of Fusion Bonded Epoxy (FBE) Coated steel rebars Deepak Kumar Kamde and Radhakrishna G. Pillai Indian Institute of Technology Madras, Chennai, Tamilnadu

10 Corrosion in Refineries & Petrochemical Industries : Failure Analysis Of A Cross Country Hydrocarbon Product Pipeline – A Case Study D. Sankara Rao, S P Singh, Madan Gopal, Sova Bhattacharya and M Sau , IOCL, Faridabad

Importance of Materials Selection, Quality Requirement and Anticipated Repair for Equipment in Petrochemical Industry Parag P Karyakarte, Dr.Barun Chakrabarti,esh, L&T Hydrocarbon Engineering, Mumbai

11 Corrosion Monitoring and Testing : A Case Study on 'AC Interference in Pipelines by Single Core HV Cables Navneet Saxena Pipeline Infrastructure Limited, and Kamlesh Bera, Reliance Gas Pipelines Limited, Navi Mumbai

12 Direct Assessment Methodology Application : Integrated Survey for cathodic protection & coating during ECDA of 4” Condensate Pipeline – A case study Sahab Singh Gurjar, Cairn Oil & Gas and Bidyut B. Baniah and Praveer Narayan Singh, Allied Engineers

13 Internal Corrosion in Pipelines : ILI Verification for subsea pipelines Mark Stone, Patricia Conder and Zach McCann, Sonomatic Ltd, Warrington, UK

14 Marine Corrosion : Breakthrough in Pulsed Eddy Current Detection and Sizing Charles Tremblay, Marco Michele Sisto, Andréanne Potvin, Eddyfi Technologies, Québec, Canada

15 Materials and Composites : Microbial Induced Corrosion Behavior of multilayer Nano composite Coatings for the marine applications Preethia, Shashi Bhushan Aryaa, Vidya Shetty, National Institute of Technology Karnataka, Surathkal, Mangaluru

Glimpses of CORCON 2019

Delegates interacting during the presentation

Discussing on during the Round Table Conference on Protective Coating Industry

Dignitaries with winners of Corrosion Awareness Award 2019

Dignitaries on the Dias during Jung Se Jung session

Cultural event during the conference

Unique interactive drumming experience enjoyed by the Delegates

16 Microbial Corrosion and Inhibitors : Cross-linked glucose derivative as a green corrosion inhibitor for mild steel in HCl solution Jiyaul Haque, Vandana Srivastava, Banaras Hindu University, Varanasi and M. A. Quraishi, King Fahd University of Petroleum and Minerals, Dhahran

17 Power Plants and Utilities : Localized oxidation of Zr-2.5 Nb alloy in a gaseous environment containing hydrochloric acid Sai Karthik Nouduru1, 2, M Kiran Kumar1 and Vivekan and Kain1, 1Bhabha Atomic Research Centre, Mumbai and 2 Homi Bhabha National Institute, Mumbai.

18 Young Student Scientist Forum : Corrosion Monitoring By E R & L P R Probes for Oil Refinery Application Akshay Sonwane, Dr. Sunil Kahar, The M. S. University of Baroda and Arindam Gupta, Advance Tech Control Pvt. Ltd., Vadodara

19 Best Poster Award : Performance characteristics of nano phase modified fly ash concrete for marine applications Sudha Uthaman1, Vinita Vishwakarma 1, D. Ramachandran 1, B. Anandkumar 2, Rani P. George 2 and U. Kamachi Mudali 3, 1 Sathyabama Institute of Science and Technology, Chennai, 2 Indira Gandhi Centre for Atomic Research, Kalpakkam, 3 Heavy Water Board, Mumbai

Understanding the Throwing Power of Galvanic Anodes in Reinforced Concrete Structures Using Numerical Simulations Naveen Krishnan and Radhakrishna G. Pillai, Indian Institute of Technology Madras, Chennai

20 Best Poster Runner –up Award : Risk Assessment of Heat Exchangers Operating with High Chlorides in Cooling Water – A case Study Vineet Sharma and Umakanthan Anand, Reliance Industries Limited, Mumbai

Smart Release Bio nano composite Coatings for Corrosion Protection of Aluminium Alloys Sarah B. Ulaeto,1,2 Anju V. Nair1, Jerin K. Pancrecious,1,2 T. P. D. Rajan,1,2* B. C. Pai 1 CSIR - NIIST, Trivandrum, Kerala 2 Academy of Scientific and Innovative Research (AcSIR), New Delhi

21 Best Poster Second Runner–up Award :Porous Micro capsule Based Super hydrophobic Coating on 304L SS and its Corrosion Properties in Chloride Medium Rasitha T.P,1, 2 S. C. Vanithakumari,1 R. P. George1 and John Philip1, 2 1 Indira Gandhi Center for Atomic Research, Kalpakkam and 2 Homi Bhabha National Institute, Mumbai, India.

CORCON 2019: Best Stalls

1.	12 Sqm – Winner	BSS Tech CP (I) Pvt Ltd
2.	12 Sqm – Runner-up	Sandvik International
3.	9 Sqm – Winner	NDT Technologies (P) Ltd
4.	9 Sqm – Runner-up	NDT Global LLC

The next date for CORCON 2020 have been announced. It will be held September 11 – 13, 2020 at Chennai Trade Center, Tamilnadu.

ASIA'S LARGEST CONFERENCE ON CORROSION

CORCON 2020

Chennai, India

11th - 13th September

27th International Conference & Expo On Corrosion

CORCON, the annual conference and expo on corrosion science and engineering held in India, is the largest event of its kind in Asia, attracting participation from academic and research institutions, public and private sector organizations including defence establishments and professionals.

Major Factors to attend the conference

- Talks by eminent speakers from distinguished scientists and top professionals around the world
- Source and purchase the latest product, technology and services (85+ Exhibitors)
- Increase your productivity to see new ideas and innovations (33 Technical Sessions)
- Networking opportunities

Exhibit at CORCON 2020

- CORCON attracts over 1000 industry leaders and decision makers from various industry in corrosion mitigation from around the world
- CORCON facilitates valuable opportunities to discover the latest resources for its attendees on corrosion issues and challenges

Technical Interactive Forums (TIF) topics:

- Integrity Management for Coating and CP system, Interference and mitigation
- Regulations and standards in corrosion
- Corrosion Monitoring and Testing
- Water Treatment
- Delivering Performance through Optimum Coating Specifications
- Corrosion Control in Concrete Structures

CALL FOR PAPERS

NIGIS invite you to submit abstracts for presentations and share your expertise to advance your career and the industry by sharing your wealth of corrosion mitigation knowledge. You are encouraged to submit your paper on the following topics:

Symposia Topics

- Biomaterials Corrosion
- Cathodic and Anodic Protection
- Coatings, Linings and Thermal Insulation
- Corrosion Control in Water Treatment Utilities
- Corrosion in Automobiles and transportation industry
- Corrosion in Chemical and Fertilizer Industries
- Corrosion in Defence Equipment & Facilities
- Corrosion in Oil and Gas
- Corrosion in Petrochemical and Refineries Industries
- Corrosion in RCC Structures
- Corrosion Monitoring and Testing
- Direct Assessment Methodology Application
- Internal Corrosion in Pipelines
- Marine Corrosion and Offshore
- Materials and Composites
- Microbial Corrosion and Inhibitors
- Power Plants and Utilities
- Young Student & Scientist Forum

Each symposia will receive best paper award

Important Dates

Paper and poster proposals will be assessed by members of the Conference Program Committee for compliance with the criteria for acceptance. All submissions will be reviewed and you will be notified once it is approved.

Abstract submission opens	ASAP
Abstracts due	31 May 2020
Full Text Paper due	15 July 2020
Presentation upload due	15 Aug 2020

NACE INTERNATIONAL GATEWAY INDIA SECTION

For any queries email
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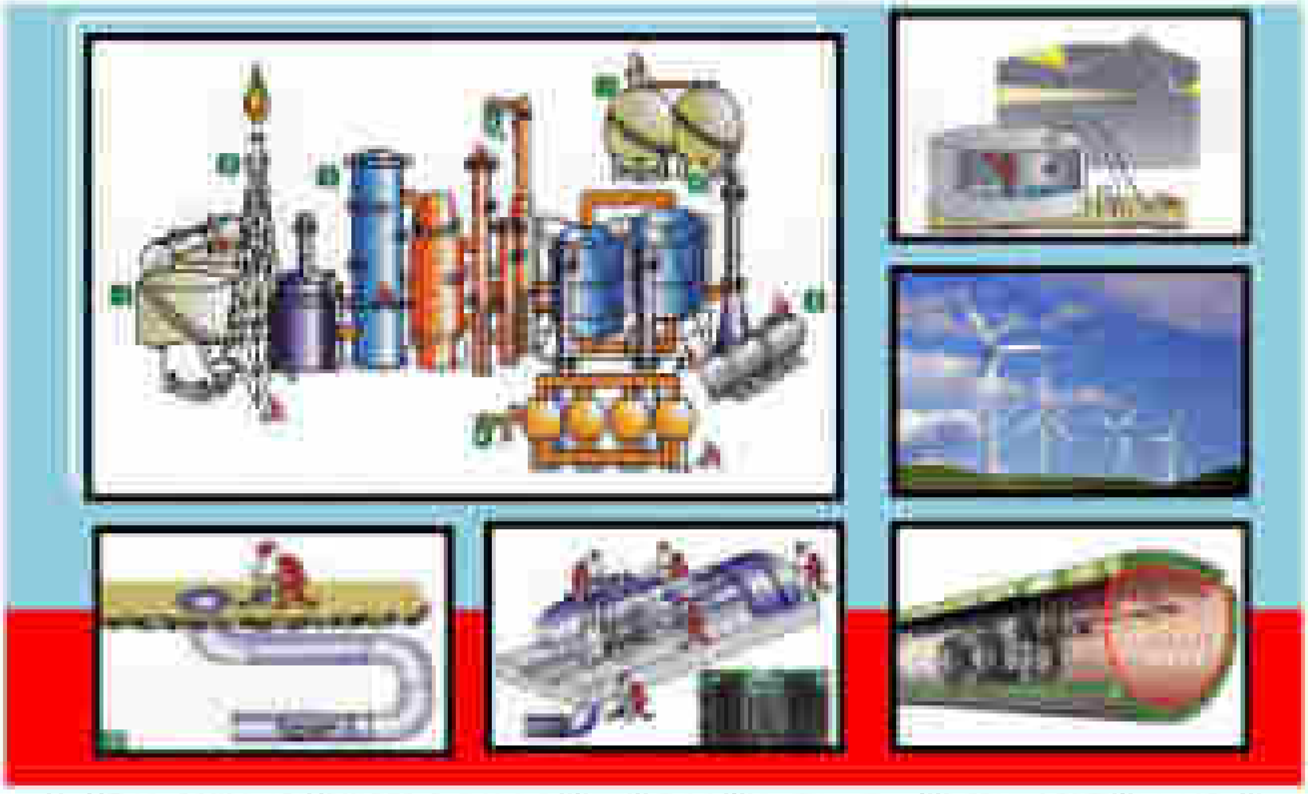

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1. Remote Field Electromagnetic Technique (RFET) :
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B. Boiler Drum to Drum tubes inspection
C. Heat Exchanger, Fin Fan & Condenser Tubing's
D. Cement Lined Buried Pipeline
E. Inspection of Insulated & Non Insulated Piping, Risers of Column & Vessels.

2. SLOFEC (Tank Floor Scanning)

3. Eddy Current inspection :- for Condenser, Heat Exchangers, Coolers etc.

4. Remote Visual Inspection (RVI) :- using various size cameras, from small diameter for heat exchangers, condensers, boilers, heaters, to large diameter crawler cameras for pipelines, cyclones , tanks , chimneys etc.
5. PAUT & TOFD

An Overview on Stress Corrosion Cracking Studies of Austenitic Stainless Steel for Nuclear Applications

Anita Toppo
Indira Gandhi Centre for Atomic Research, Kalpakkam

Introduction

Austenitic stainless steels are major structural materials for fast breeder reactors (FBRs). They have been employed worldwide as core structural materials in fast breeder reactors because they exhibit good mechanical properties at high temperatures, are compatible with liquid sodium and the ceramic fuel, design data is available in codes, and are easily available in market. A 500 MWe Prototype Fast Breeder Reactor (PFBR) is in the commissioning stage at Kalpakkam. It uses type 316LN stainless steel (SS) for high-temperature structural components in view of improved weldability, code data availability and minimum scatter in mechanical properties.

One of the major challenges of having SS as a principal structural material is its tendency to undergo corrosion attack. There are many forms of corrosion which are categorized under general corrosion and localized corrosion attack. General corrosion results in thinning of component whereas localized corrosion attack takes place at a localized region and other parts appear to be as sound as original. This affects the performance of structures and mechanical systems and can cause catastrophic failures [1].

Stress corrosion cracking (SCC) in stainless steel is encountered in almost all types of industries like steam power plants (using fossil or nuclear fuels), chemical plants, petrochemical refineries, and food processing industries. Stress corrosion cracking is a time-dependent degradation process can be defined as premature failure of material due to combined action of tensile stress and specific corrosive medium neither of which acting alone would cause a failure. SCC is particularly troublesome form of corrosion for several reasons: 1. Stress corrosion cracks develop in otherwise non-cracking systems, reduces the usefulness of materials such as mechanical properties. 2. Cracking can take place with little or no applied stress (the residual stress from machining, welding or quenching being sufficient), and with only a few parts per million of aggressive species present. 3. Cracks may propagate rapidly once they have been initiated making them difficult to detect prior to failure.

In our laboratory, extensive studies were undertaken in order to understand the mechanism of SCC in stainless steel and its welds. Studies on effect of heat input on nitrogen-containing 316 stainless steel weld metal [2] were conducted. Four different heat inputs i.e. 3.07, 4.8, 7.0, 7.41 kJ /cm were introduced into the weld by changing the welding parameters. SCC studies were carried out on these specimens using constant load testing techniques. Time to failure (t_f) was the assessment criteria for SCC resistance.

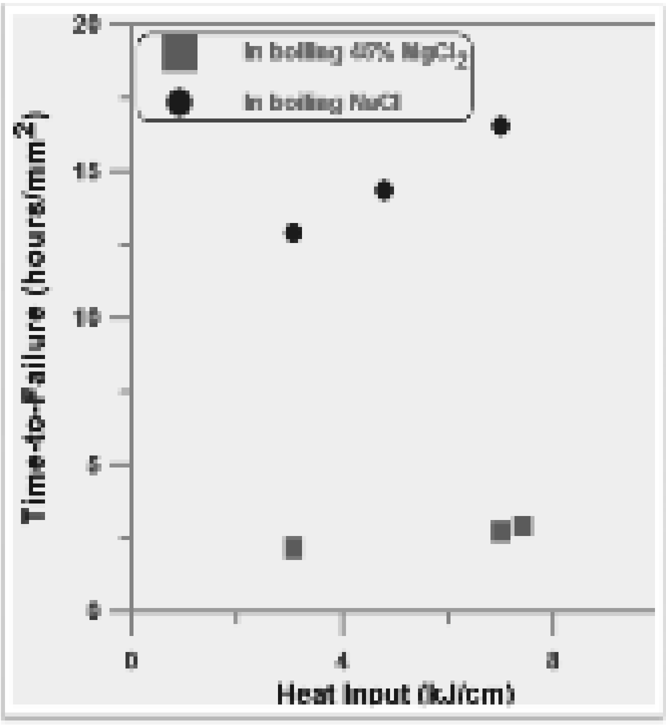


Fig.1. Effect of heat input on SCC behaviour weld metal

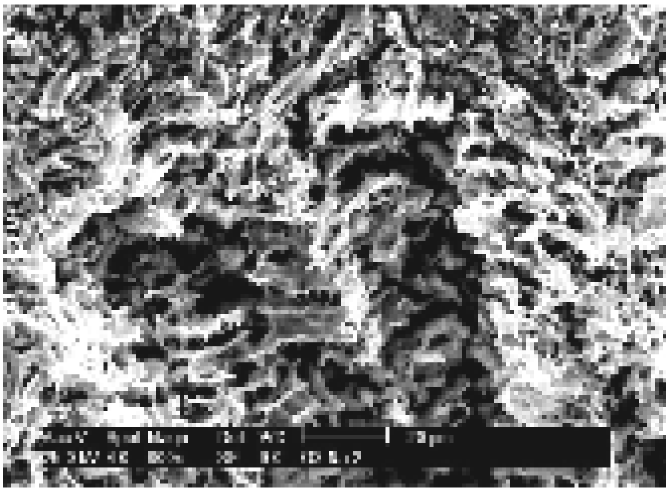


Fig.2. Stress-assisted dissolution of δ - 316 ferrite in weld metal tested

The t_f in a boiling 5 M NaCl + 0.15 M Na_2SO_4 + 2.5 ml/L HCl solution increased with increasing heat input to the weld metal, while a marginal decrease in the CCP was observed as seen in Fig. 1. In boiling 45% $MgCl_2$ solution, this increase in t_f was marginal. In a boiling solution of 5 M NaCl + 0.15 M Na_2SO_4 + 2.5 mil/L HCl, failure of the weld metal occurred by dissolution of δ-ferrite as shown in Fig. 2 and transgranular SCC (TGSCC) of austenite; in the boiling solution of 45% $MgCl_2$, failure was due to cracking of the δ-ferrite/austenite interface and TGSCC of austenite. The implication of this study is that in a multipass weld, provided sensitization of HAZ is avoided, using high heat input for welding should not pose a problem from the point of view of SCC resistance of the welded joint.

Another set of experiments were carried out on AISI type 316LN SS in different metallurgical condition using fracture mechanics approach. The fracture mechanics approach is useful since it gives a quantitative measure of the threshold stress levels and crack growth rates. In this work, the stress corrosion crack growth data was generated on indigenously made AISI Type 316L (N) SS plates of 12 mm thickness and the crack growth data was compared with that of the imported plates of the same grade.

Stress corrosion studies were carried out to compare the SCC resistance of mill annealed (SS-1) 316LN (0.07 wt% N) with that of sensitized (973 K for 800 hours) and 15 % cold-worked SSs. Mill annealed SS which was indigenous was also compared with the imported variety of 316LN SS (SS-2). Compact tension (CT) specimens were machined from the indigenous 12 mm thick AISI type 316L (N) SS plates. The specimens were fabricated as per ASTM E399 **[3]**. SCC tests were carried out in boiling aqueous solution of 5M NaCl + 0.15M Na_2SO_4 + 2.5 ml/l HCl (b.p = 381.5 K; pH = 1.3) at various values of threshold stress intensity factor, K_I. The threshold stress intensity parameter, K_{ISCC}, was defined as the value of K_I where the crack growth observed was 5 x 10^{-11} m/s.

The dependence of crack growth rate on K_I is shown in Fig. 3 for 316LN SS in different metallurgical conditions. Some important points inferred from this work [**4**] are: (i) indigenous type 316L(N) SS possessed lower plateau crack growth rates (PCGR) and higher values of K_{ISCC} than the imported variety, (ii) cold-worked material possessed lower PCGR and lower value of K_{ISCC} vis-à-vis annealed material, and (iii) thermally aged material possessed higher PCGR than annealed material.

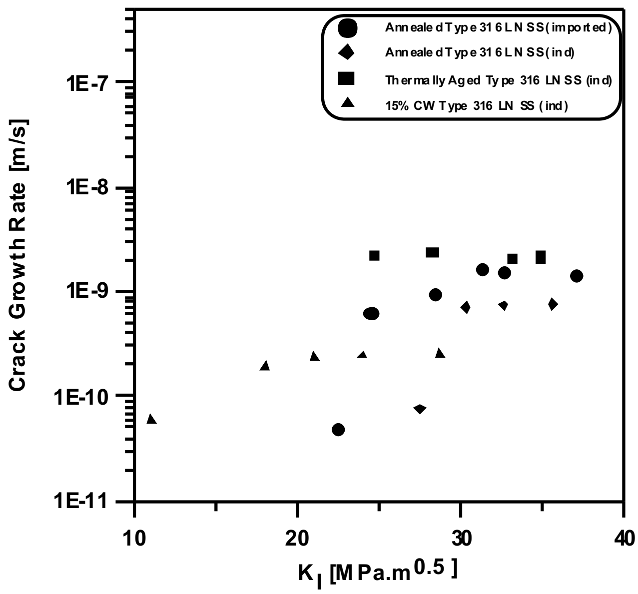
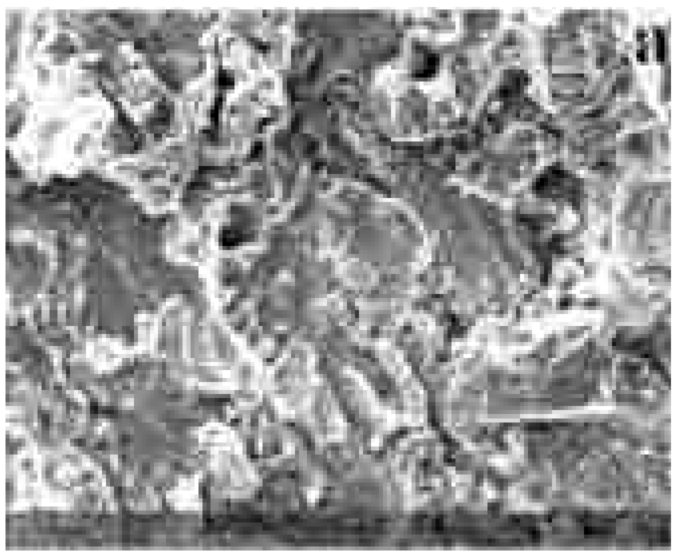


Fig.3. Crack growth rates varying with different K_I values for 316LN SS in different metallurgical conditions



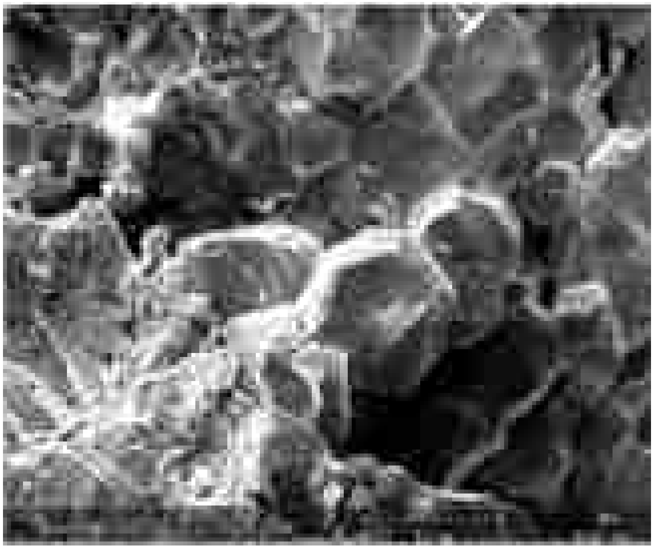


Fig.4. SEM shows (a) transgranular mode of failure for mill annealed, cold worked SS and (b) transition from transgranular to an intergranular mode of failure for thermally aged

SS-2 had a PCGR, which was nearly 2.5 times lower than that of SS-1, in the annealed condition. Higher copper content and lower effective grain boundary energy in SS-2 caused its increased resistance to SCC. Cold working reduced the PCGR and the threshold stress intensity parameters vis-à vis annealed material. Thermal aging led to an increase in the plateau crack growth rate vis-à-vis annealed material. Type 316 N weld metal showed lower values of K_{ISCC} and J_{ISCC} and higher crack growth rates than type 316LN weld metal. Cracking initiated in the transgranular mode in all the metallurgical conditions as shown in Fig. 4 (a). A transition to intergranular cracking mode was observed in thermally aged material as shown in Fig. 4(b). Besides transgranular cracking of the austenite, dissolution of 8-ferrite was observed in the weld metal as shown in Fig. 2.

The design life of PFBR is of the order of 40 years, but there is an interest to increase the design life of future commercial FBRs to at least 60 years. Hence, it became necessary to develop type 316LN stainless steels and characterize them for their microstructural, mechanical and corrosion properties. High nitrogen steels where nitrogen is up to 0.22 wt% was evaluated for its corrosion resistance and compared with 0.14 and 0.07 wt% nitrogen-containing SS. SCC studies were carried out on round tensile specimens of three different nitrogen-containing stainless steel in different metallurgical condition (mill annealed, sensitized at 973K for 100 h and 15 % deformed) in acidic chloride medium. Tests were carried out using constant load testing techniques. Open circuit potentials were monitored during SCC tests. The potential at which the specimen undergoes SCC is termed as critical cracking potential.

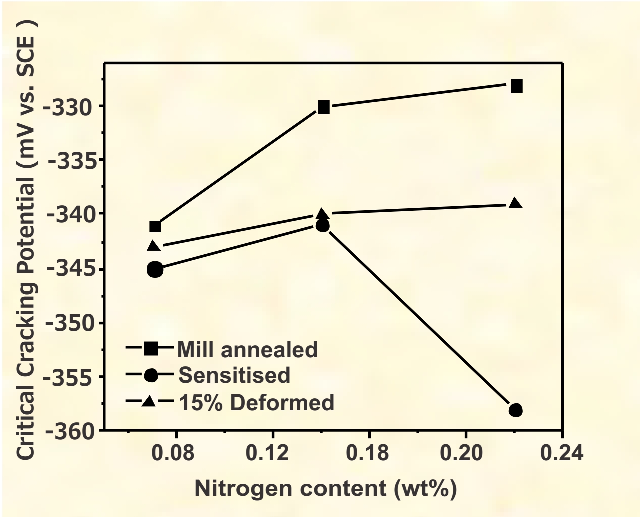


Fig.5. Critical pitting potential variation with varying nitrogen content

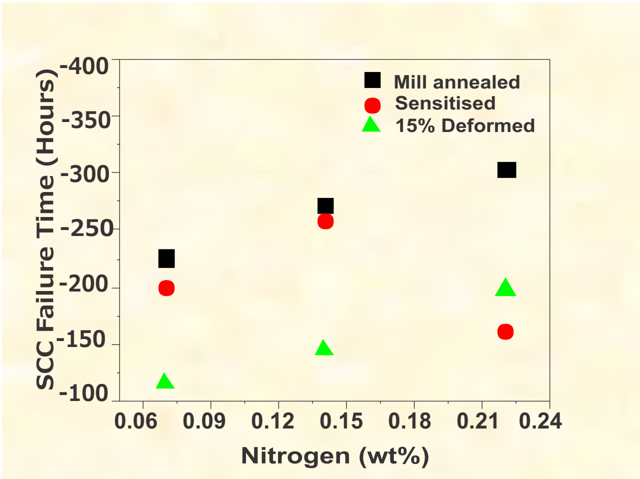


Fig. 6. SCC resistance of nitrogen steel in different metallurgical condition

Critical cracking potential (CCP) increased with increasing nitrogen content in mill annealed condition as well as in cold-worked condition. Sensitized stainless steel showed decrease in cracking potential for 0.22 wt% nitrogen steel as shown in Fig. 5. On studying the SCC resistance following observation was made that: (i) in mill annealed 316LN SS, time to failure (t_f) increased with increasing nitrogen, (ii) in 15% cold work, SCC resistance increased with increasing nitrogen content but resistance was lower than that of annealed stainless steel, (iii) whereas in sensitized steel, SCC resistance increased up to 0.14 %N and beyond that there was drastic reduction in its resistance as observed from Fig. 6. In general it was observed that in mill annealed condition, a higher

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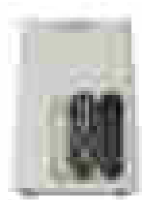
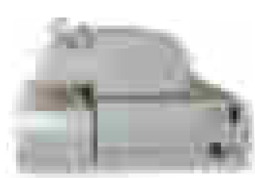
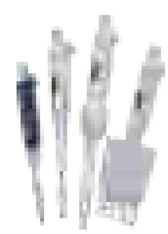

potentiostat/galvanostat


Particle size analyser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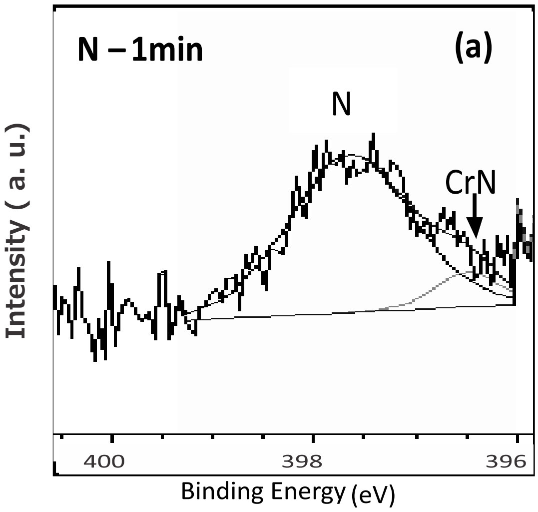
amount of nitrogen improves stress corrosion cracking resistance by improving the passivity of the film formed on the steel surface in the environment. X-ray photoelectron microscopic studies showed beneficial effects of nitrogen on the film formed on 316LN SS. Nitrogen enrichment was detected on the surface of 316LN SS after exposure to acidic chloride medium. Leinonen and Hanninen [**5**] reported increased resistance to SCC of austenitic stainless steel alloyed or implanted with nitrogen due to improved passive film stability on addition of nitrogen. Laser Raman studies in our laboratory showed the presence of chromium and molybdenum oxide film at the surface for three different nitrogen-containing SS [**6**].



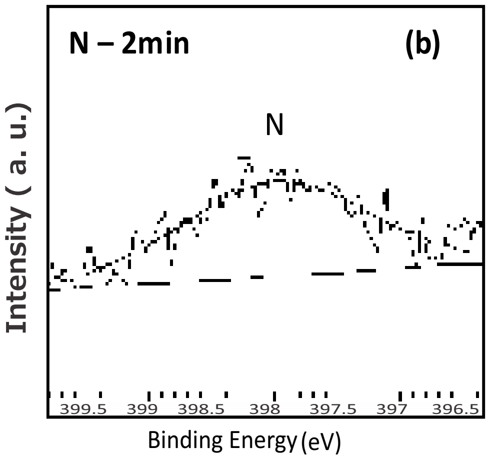


Fig.7. De-convoluted high resolution spectra obtained from type 316LN stainless steel with 0.22 wt.% nitrogen after test (a) N after 1 min sputtering (b) 2 min sputtering

The effect of nitrogen on SCC behavior of sensitized stainless steel shows that nitrogen additions up to 0.14 wt% increase the SCC resistance, while further addition of 0.22 wt% N results in deterioration in SCC resistance. Also, it is reported that as the nitrogen concentration increases, its ability to promote chromium enrichment along the grain boundary also increases [**7**]. A similar observation was made by Bali et al [**8**] which showed that nitrogen addition up to 0.16 wt% has beneficial effects on IGSCC. However this effect is not felt for 0.22 wt% N as SCC resistance deteriorates. This is because beyond solubility limit depletion of chromium along the grain boundaries reaches maximum due to very high volume fraction of Cr_2N precipitate. The detrimental effect of high nitrogen content has also been reported by some other workers [**9**] where it has been found that compositions with nitrogen contents over 0.19 wt% are susceptible to IGSCC due to the continuous precipitation of Cr_2N at the grain boundaries. Truman et al [**10**] reviewed various studies relating N content to stress corrosion and corrosion fatigue and concluded that increase in N level reduces the effects of stress- enhanced corrosion. However, if the N content exceeds its solubility limits, Cr_2N will precipitate and deplete the matrix of Cr, thus reducing passivity.

Cold working introduces higher strains at the surface, resulting in the introduction of residual stresses [**11**] in the material. Also, cold working results in increased defect density in the bulk as well as on the surface. This decreases the stability of the passive film for cold-worked stainless steel. Hence, cold worked steel shows improvement in SCC resistance with increasing nitrogen content but to lower extent than that of mill annealed 316LN SS.

Online monitoring techniques such as acoustic emission (AE), electrochemical noise (ECN) can be used to monitor SCC [**12**]. The AE technique was used in one of the works to study the crack growth. Crack growth measurements were carried out in the range of stress intensity factor of 13-26 MPa $m^{0.5}$5 in a 45% $MgCl_2$ solution at 413 K. The average crack growth rate was 2.33×10^{-8} m/s. Acoustic emission signals were collected during the SCC and are shown in Fig. 8 as AE cumulative counts with respect to time. AE with amplitudes ranging from 27.6 to 46.5 dB with different counts, energy and rise times occurred during the course of the tests. The AE was found to be continuous prior to the initiation, which was identified by the sudden increment in AE energy and counts. The time gap between AE events increased during initiation. The time gap between AE events increased further with increasing crack growth. 3. Detailed analysis of the AE signals indicated that the cause for majority of the acoustic

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emissions to be plastic deformation ahead of the crack tip. The cracking was found to initiate and propagate in the transgranular mode.

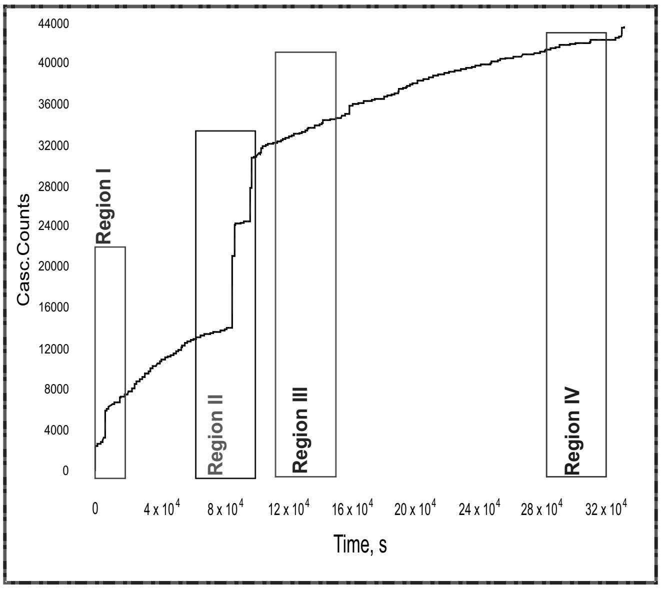

Fig.8. AE signals during SCC in AISI type 316 LN stainless steel

Summary:

Stress corrosion cracking can be costly where plant damage occurs and much more so when lives are lost. Hence, a complete understanding of this form of localized attack is must. The above studies show SCC failure cannot be avoided but can be delayed by careful selection of material, chemical composition, range of potentials, etc. Different testing methods such as fracture mechanics, constant load testing techniques can be used to study mechanisms, select best material for an environment, identify the SCC causing species, develop new alloys and control tests to ensure proper fabrication procedure.

REFERENCES:

1 M.L. Bauccio and R. Williams, Corrosion in the Aircraft Industry, in Metals Handbook, 9th ed. Vol. 13: ASM International, 1987, pp. 1019-1057

2 T. Anita, H. Shaikh, H.S. Khatak and G. Amarendra, Effect of heat input on the stress corrosion cracking behaviour of weld metal of nitrogen added AISI type 316 stainless steel, Corrosion 60 (2004) 873-880

3 ASTM E399-06, Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness KIc of Metallic Materials, (2006)

4 H. Shaikh, T. Anita, R. K. Dayal and H. S. Khatak, Effect Of Metallurgical Variables on the Stress Corrosion Crack Growth Behaviour Of AISI Type 316LN Stainless Steel, Corros Sci 52 (2010) 1146-1154

5 H. Leinonen and H. Hanninen, Materials Science Forum, 318-320 (1999) 545 – 552

6 S. Ramya, T. Anita, H. Shaikh and R.K. Dayal, Laser Raman microscopic studies of passive films formed on type 316LN stainless steels during pitting in chloride solution, Corrosion Science 52 (2010) 2114-2121

7 S. Degallaix, J. Foct and A. Hendry, Materials Science and Technology, 2 (1986) 946

8 S.C. Bali, V. Kain and V.S. Raja, Corrosion 65 (2009) 726-741

9 R. S. Dutta, P. K. De and H. S. Gadiyar, Corrosion Science, 34 (1993) 51 - 60

10 E. Truman, "Effects of Nitrogen Alloying on Corrosion Behavior of High Alloy Steels," High Nitrogen Steels, HNS-88, Proceedings of the International Conference, Organized by The Institute of Metals and the Societe Francaise de Metallurgie and Held at Lille in France on May 18-20, 1988, Edited by J. Foct and A. Hendry, The Institute of Metals, 1989

11 Yoko.Ohnishi, Atsush. Yamamoto, Harushige.Tsubakino, Mititaka.Terasawa, Shigeo. Nakahigashi, Advanced materials research Vol 26-28 (2007)p 1287-1290

12 H. Shaikh, R. Amirthalingam, T. Anita, N. Sivaibharasi, T. Jaykumar, P. Manohar, H. S. Khatak, Evaluation of Stress Corrosion Cracking Phenomenon in an AISI Type 316LN Stainless Steel Using Acoustic Emission Technique, Corrosion Science, 49 (2007) 740-765

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A Report – NACE India Educational & Training Program

NACE International Gateway India Section (NIGIS) had organized three Educational & Training Programme on "Pipeline Corrosion" from 25 – 27 July 2019; 14 – 16 November 2019 and "Fundamentals of Coating & Lining" from 23 – 24 August 2019 at Hotel Rodas, Powai, Mumbai.

Pipeline Corrosion training programme covers various aspects of corrosion of pipelines and methods available for prevention and control of their corrosion. The intention is to arm pipeline personnel with sufficient knowledge on pipeline corrosion.

Fundamentals of Coating & Lining training programme covers various aspects of Protective coatings. This program trains coating professionals to properly understand the technical aspects of surface preparation and application of a protective coatings system on a variety of structures.

Every organisation needs to have employee training to improve skills or add to the existing level of knowledge so that employee is better equipped. The companies which were participated in these training program are Amar Fabricators & Engineers, Asian Paints PPG Pvt. Ltd, BPCL, CPCL, Dip-FlonEngg. & Company, DNP Limited, DNV GL AS, GAIL India Ltd, Graco India Pvt. Ltd., Gujarat Gas Limited, HPCL, Hitech Civil Engineers (P) Ltd., HMPL, IOCL, Injo Technical Services, Inspecndt, Jindal Stainless Ltd., Jyoti Innovision Pvt. Ltd, L&T Hydrocarbon Engg Ltd, Larsen & Toubro Ltd., NRL, ONGC, OIL, Pipe Hangers & Supports Private Ltd, Pipeline Infrastructure Limited, Pradeep Metals, Reliance Gas Pipelines Limited, RIL, Sabarmati Gas Ltd, Shantidevi Chavan Institute of Technology, Southern Railway, STP Limited, Techno Coat Systems India, Tesla Transformers (India) Ltd., VIT-Vellore.

The faculties for these training program were eminent professionals from industry and academicians included Mr. N Manohar Rao, Mr. Denzil D'Costa, Mr. Pankaj Panchal, Mr. Aqeel Ahmad Khan, Mr. K Shashidhar, Dr. Anil Bhardwaj, Mr. Mahesh Kumar Aradhye, Mr. K. B. Singh, Prof V S Raja, Mr. Swapnil S. Varadkar and Dr Bhupendra Gaur. These training programs was co-ordinated by Mr. Rishikesh Mishra.

The training program had stupendous success and received high appreciation from participants.

Pipeline Corrosion participants from 25 - 27 July 2019

Fundamentals of Coating & Lining participants from 23 -24 August 2019

Pipeline Corrosion participants from 14 - 16 November 2019

Participants receiving Participant Certificate from Mr. N. Manohar Rao, Trustee, NIGIS

A Report on 13th Electrochemistry & Corrosion Camp, NIGIS South Zone

NACE International India Gateway Section (South Zone) has started the "Electrochemistry & Corrosion Camp" in the year 2007 as an outreach programme for motivating the school children on the relevance and importance of corrosion science and technology under the advise and leadership of Dr. U. Kamachi Mudali, Advisor, NIGIS South Zone & Chairman, NACE International Gateway India Section. The programme involves taking the students for a tour to the electrochemistry and corrosion related industries on the first day, followed by display and demonstration of poster and model by students on specific topics in Electrochemistry & Corrosion, the next day. The objective of ECC was to promote the importance of corrosion science and electrochemistry to students of Class X, XI, and XII and further their interest in basic science and technologies.

The 13th annual "Electrochemistry & Corrosion Camp" (ECC–2019) for the year 2019was conducted during 16-17, August 2019 at Multipurpose Hall, DAE Township, Kalpakkam. A total of about 72 bright, young students from various schools in Chennai, Kalpakkam and Pondicherry attended this 2-day program along with 18 teachers who have escorted and motivated them in electrochemistry and corrosion. Children from Class X, XI and XII in a group of four were invited to present poster on topics like corrosion, Electrolysis, Electro-synthesis, Pioneers in Electrochemical Sciences, Electroplating, Cathodic Protection, Electrodyalisis, Fuel-cells, Electrochemical Sensors, Electrophoresis, Batteries, Electrochemistry and Clean Energy, Electric Double Layer, etc,.

On the first day, 16 August 2019, students were taken for an industrial visit to an electroplating plant, MBI Metalloys Pvt Ltd., Ambattur, Chennai and anti-corrosion and cathodic protection unit; Ti Anode Fabricators, Chennai; and finally to a research institute, National Institute of Ocean Technology (ESSO-NIOT), Pallikaranai, Chennai. MBI Metalloys demonstrated nickel and gold plating techniques for the students. At Ti Anode Fabricators, students observed the development of the anodes and various other sensors to save power, resist corrosion, reduce maintenance cost and avoid product contamination. National Institute of Ocean Technology (ESSO-NIOT), has given interesting presentations on how NIOT developed reliable indigenous technology to solve the various engineering problems associated with harvesting of non-living and living resources in the Indian Exclusive Economic Coastal Zone. Experts in NIOT also showed the students how electrochemical techniques play a major role in deep sea technologies like ocean observation systems, deep sea mining, etc., The first day industrial visit program ended at 17.30 hrs.

On the second day 17 August 2019, the program was held at Multipurpose Hall, DAE Township, Kalpakkam, from 0900 to 1730 hrs. Poster displasy was followed by power point presentation for 5 minutes each by the school groups. This year, the three judges who evaluated the competition were Dr. Puspalatha Rajesh, Dr. M.P. Srinivasan Senior Scientists from Water & Steam Chemistry Division, BARCF, Kalpakkam, and Dr. T. M. Sridhar, Head Incharge, Analytical Chemistry Department, University of Madras, Chennai. Post lunch session started with the welcome address by Dr. S. Rangarajan, President, NIGIS-SZ, who welcomed all the guests, judges and the participating school children and their teachers for the valedictory function. He also highlighted about the genesis of ECC and how it continues as a regular annual event of NIGIS (SZ) since 2007 under the guidance of founding convener, Dr. U. Kamachi Mudali, currently the Advisor to South Zone Section and Chairman NIGIS, Mumbai and also the Chief Executive and Chairman of Heavy Water Board, Department of Atomic Energy, Mumbai. Dr. Kamachi Mudali, Chairman, NIGIS, spoke about NACE International and highlighted the India Section activities. Then the Chief guest was introduced by Dr. Radhakrishnan G.Pillai, Secretary, NIGIS SZ. This year the Chief Guest was Prof. Gurmeet Singh, Vice Chancellor, Pondicherry University. He was pleased to note the posters displayed by the students and their involvement in the topics of competition. He suggested few guidelines to the students on how to make an effective presentation. In his motivating lecture he talked about the values of education and the goals the students should have in designing the future career. He was highly appreciative of the unique program and lauded the organizers for conducting the program every year. The Chief Guest also suggested the students to not to aim for lucrative jobs, and they should become enterprenuers and provide job opportunities to many. He provided a few examples for plausible enterprenuer opportunities. There were fruitful interactions between the speaker and the students after the valedictory session.

Chief Guest Prof. Gurmeet Singh distributed the competition prizes and merit certificates. In the category of Class X: First Prize: Atomic Energy Central School, Anupuram; Second Prize: Atomic Energy Central School No.1, Kalpakkam; Third Prize: PSBB Millenium School, Chennai; Consolation Prize: (i) Peniel Matriculation Higher Secondary School, Chennai & (ii) Vanavani Matriculation Higher Secondary School, Chennai.

For the category Class XI-XII: First Prize: Amalorpavam Higher Secondary School, Puducherry; Second Prize: Kendriya Vidyalaya No.1, Kalpakkam; Third Prize: (i) Vanavani Matriculation Higher Secondary School, Chennai and (ii) PSBB Millenium School, Chennai; Consolation Prize: Smt. Ramkuwsar Devi Fomra Vivekananda Vidyalaya, Chennai. Mementoes were distributed to appreciate the 18 teachers who have guided and motivated the students to participate in the event.

In the concluding feedback session, students expressed how they enjoyed the industrial visit particularly the gold plating demonstration in the factory and seeing the deep sea buoys in NIOT and the teachers thanked the organizers for this student motivating program. The program ended with the vote of thanks by Dr. T. Subba Rao, Convener, ECC-2019.He thanked the all the organizations who supported this program. He also thanked Dr. U. Kamachi Mudali, Chairman, NACE International Gateway India Section, Mumbai, Advisor, NIGIS SZ for his guidance, support and keen interest in sustaining this program and for travelling from Mumbai to make this a wonderful and enjoyable event. He also expressed his gratitude to Prof. Gurmeet Singh, for sparing his valuable time and being the Chief Guest of ECC-2019. The program concluded with national anthem.

Dr. U. Kamachi Mudali, Chairman NIGIS, Mumbai honouring Chief Guest Prof. Gurmeet Singh with a memento.

First prize winning team from Amalorpavam Higher Secondary School, Puducherry receiving merit certificate from Chief Guest.

Left to right - Dr. S. Rangarajan, Chairman, EC-2019, Dr. U. Kamachi Mudali-Chairman NIGIS, Mumbai, Prof. Gurmeet Sigh, VC, Pondichery University (Chief Guest), Dr. T. Subba Roa, Convener-ECC 2019.

Computer and physical scale modeling in cathodic protection

Harvey P. Hack, PhD
Northrop Grumman Corp., Undersea Systems

ABSTRACT

This paper presents an introduction to scale modeling for cathodic protection. It introduces computer modeling, using finite elements and boundary elements, physical scale modeling, and qualitative prediction using Wager Number analysis and describes the advantages and disadvantages of each. The importance of using polarization curves that are representative of the environment of the full sized structure as boundary conditions for computer modeling is emphasized, and a method for developing such curves is described. Edge and flow effects are discussed. A qualitative analytical tool called Wagner Number analysis is presented.

INTRODUCTION

Full-sized structures are often too large to perform testing on to determine current and potential distributions from cathodic protection systems. It is often impractical on full-sized structures to modify the number and locations of anodes to optimize protection. Three methods to determine the levels and special distributions of cathodic protection that do not require testing on the full-sized structure will be described herein. These are physical scale modeling, computer modeling, and qualitative modeling. These techniques are discussed in this paper, along with how to provide appropriate boundary conditions for the first two.

A large portion of this paper is based on a paper presented in Corrosion Reviews in 1997 [1], although additions to that material are presented here.

PHYSICAL SCALE MODELING

Physical scale modeling is a method whereby a small-scale replica of the relevant portions of the full-sized structure is made and tested. The ratio of lengths of the scale model to the lengths of the full-sized structure is called the scaling factor; for example if the scale model is 1/10 of the size of the full-sized structure, then the scaling factor is 1:10. In a physical scale model, certain areas of the model are designated as anodes and those areas are wired to the positive terminal of a power supply, while other areas are designated as cathodes and are wired to the negative terminal. Sometimes separate power supplies are used for separate anodes, and sometimes resistors are placed in the electrical circuits to simulate resistances in practice. The model is then placed in an electrolyte where potential distributions can be measured. Sometimes the cathodes are segmented so that current distributions also can be measured.

In order to understand how this type of dimensional scaling works, the scaling effects must be known for electrochemical potential, electrolyte resistance, edges, flow, and the anode and cathode polarization resistances. These will be discussed one-by-one below.

ELECTROCHEMICAL POTENTIAL

The electrochemical potential of a corroding surface is a function of the material, its exposure history, and the environment into which it is placed. For most modeling, potential and current density are not scaled, i.e. they are the same in the model as in the full-size structure. This makes testing easier and the results of any modeling easier to understand.

ELECTROLYTE RESISTANCE [2]

Since in cathodic protection current flows in a complete circuit from the anode, through its polarization layer, through the water surrounding the structure, through the cathode polarization layer, to the cathode, and then through any resistances of the metallic path that completes the circuit. All of these must be considered to understand scale modeling. Usually metal path resistance is negligible compared to the other resistances of the circuits; therefore only the resistances are of interest.

Scaling of electrolyte resistance can be understood by considering Figure 1.

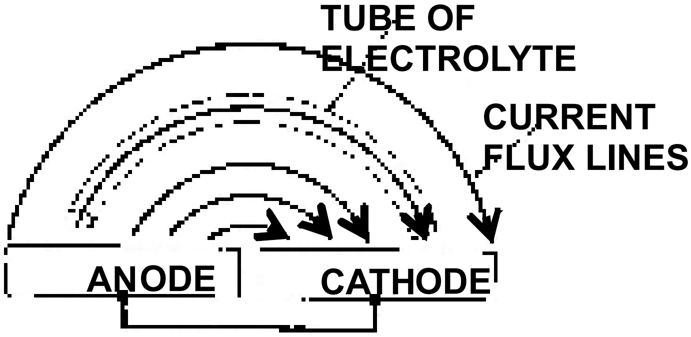
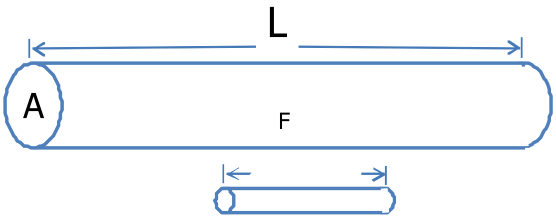


Figure 1 – Current Flow from the Anode to the Cathode through the Electrolyte

This figure shows simplified current flux lines indicating how the current flows from the anode to the cathode. Considering a tube of electrolyte surrounding a flux line allows prediction of resistance scaling, Figure 2.



F

$A_S = A_F/100$ $\quad L_S = L_F/10$

$$R_F = \rho_F * L_F/A_F$$

$$R_S = \rho_S * L_S/A_S = \rho_S L_F/10/(A_F/100) = 10R_F$$

L = length
A = area
R = resistance
ρ = resistivity
I = current density
F = full scale
S = reduced scale

Figure 2 – Full Scale and Scaled Tubes of Electrolyte

The resistance of the full scale tube of electrolyte is RF = ρF · LF / AF and that of the scaled tube is RS = ρS · LS / AS. To get the correct potential drops in the scale model, the resistances must be the same as full scale, since we want potentials and current densities to be the same. If a scaling factor of 1:10 is assumed, then the area of the scaled tube is 1/100 of the area of the full sized tube and the length of the scaled tube is 1/10 of the full sized tube. This results in the resistance of the scaled tube being 10 times, or the inverse of the scaling factor, that of the full sized tube. To make these resistances equal, the electrolyte resistivity must therefore be increased by the scaling factor. This is usually done by diluting the electrolyte. Without this dilution, a physical scale model will not give proper results.

ANODE AND CATHODE POLARIZATION RESISTANCES [2]

Polarization resistance can be visualized by considering electrochemical potential as a function of distance from the electrode.

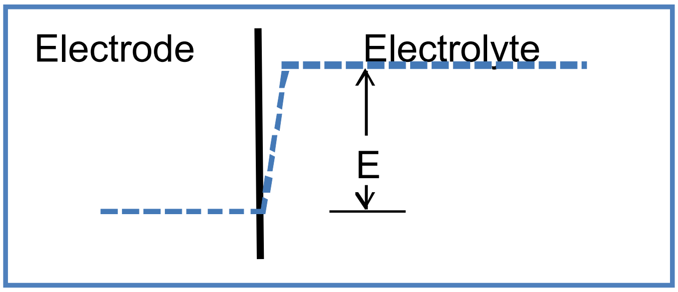


Figure 3 – Potential as a Function of Distance from an Electrode with No Current Flowing

When no current is flowing, the reactions at the surface of the anode or cathode will generate a step in potential in the electrolyte adjacent to the electrode, Figure 3. When current is flowing, two additional effects will occur. The first is that the magnitude of this step will change, which is called polarization, shown as two separate steps for clarity in Figure 4, although this is really a single step.

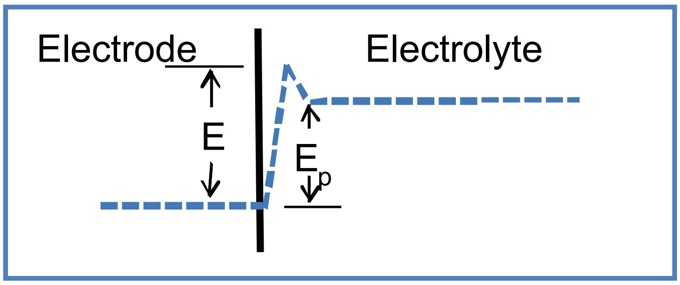


Figure 4 – Polarized Potential with Current Flowing

The second effect is that the current flowing through the resistance of the electrolyte will create a potential drop, or an IR drop, as in Figure 5.

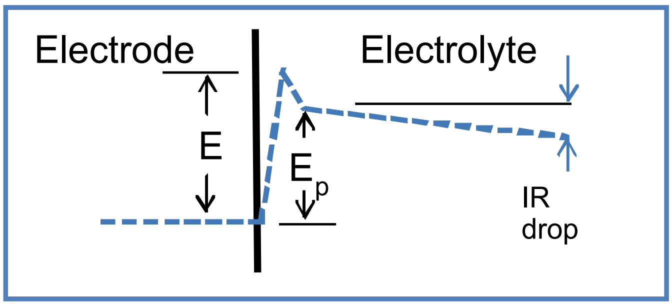


Figure 5 – Polarized Potential Along with Electrolyte IR Drop

This effect is shown for a complete sacrificial anode cathodic protection system in Figure 6.

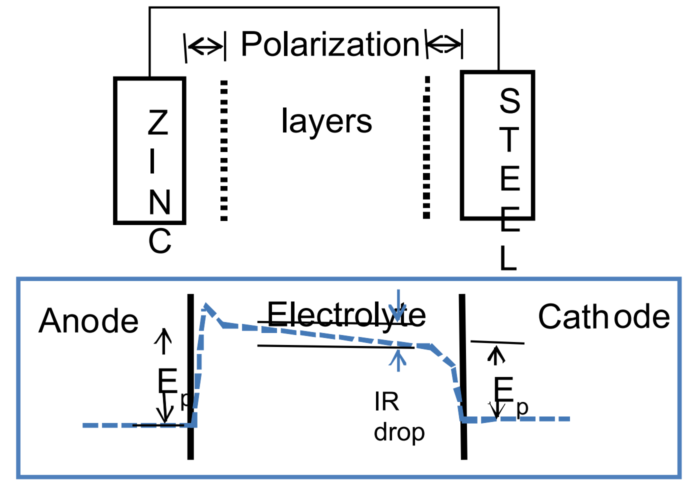


Figure 6 – Potential Profiles in a Sacrificial Anode Cathodic Protection System (upper=physical arrangement; lower=potentials)

The effect looks similar for an impressed current cathodic protection system, Figure 7, except that the potential in the metals of the anode and cathode must be offset by the power supply voltage.

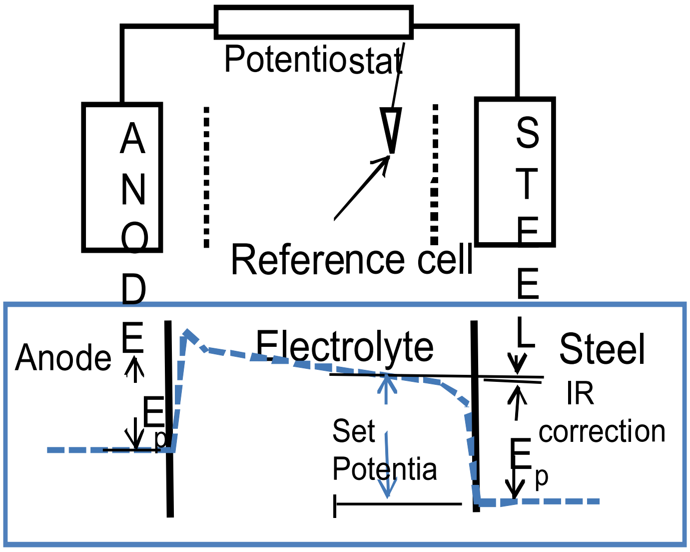


Figure 7 – Potential Profiles in a Impressed Current Cathodic Protection System (upper=physical arrangement; lower=potentials)

This figure also shows the relationship between the set potential of the impressed current system, which is always measured at the controlling reference cell, and the other potentials in the system. These last two figures illustrate why polarization resistances must be properly scaled, along with the electrolyte resistance, to obtain a potential distribution in the scale model that is similar to that in the full-size structure.

The advantages of physical scale models is that they usually look just like the full-scale structures, making them intuitive to understand, computers and software are not required for getting results, and it is fairly easy to measure the resultant potential profiles in liquid electrolytes.

The disadvantages of physical scale modeling are that current density profiles are difficult to measure without segmenting the cathodic electrodes, electrolyte resistivity must be increased by the scaling factor, normally done by dilution, and potential profiles will be difficult to measure if the electrolyte is a soil. Also the diluted electrolyte will have different surface reactions, and therefore generate different polarization resistances than the full scale electrolyte. This normally means that the electrode surfaces must be pre-conditioned to give similar polarization behavior as the full scale surfaces would experience. This includes buildup of corrosion products or calcareous deposits, and makes time-dependency of results difficult to model.

COMPUTER MODELING

The mathematics involved in computer modeling is too complex to go into in this paper; however the following, admittedly simplistic, explanation is offered.

FINITE ELEMENT THEORY [3]

In finite element analysis, the electrolyte surrounding the full size structure is divided into many small pieces, called finite elements. Computer software then calculates the IR drop through each piece using a three-dimensional form of Ohm's Law. It then makes sure that the current going into each face of each piece is the same as the current going out of the face of the adjacent piece. This involves simultaneously solving at least as many equations as there are finite elements; and typically many more. At the anodes and cathodes there is no adjacent element, so boundary conditions must be defined as the relationship between voltage and current, i.e. polarization behavior. For the model to work correctly, the boundary conditions used must accurately reflect those on the actual structure being modeled. The model can be run with the boundary conditions changing over time, usually based on having polarization curves that are a function of the amount of current passed. Changes of electrolyte with location or depth can easily be modeled, as can edge effects; however effects of flow are more difficult to model and are typically modeled by incorporating flow effects into the polarization curves used as boundary conditions on the relevant surfaces.

Finite element modeling can predict total protection current, current distribution, potential distribution, and given additional boundary conditions, stray current corrosion.

BOUNDARY ELEMENT THEORY [4]

Boundary element modeling involves modeling not the electrolyte surrounding the structure, but the structure surfaces only. This includes the anodes, cathodes, and surfaces that current can't penetrate such as non-metals and the water surface. With fewer, and two-dimensional, elements to model, this makes modeling much easier. Results are typically plotted as colors on the surfaces, making visualization of the results much easier. Although boundary element analysis gives no information about potentials around the structure in the electrolyte, this information can be obtained by post-processing the results. Boundary element modeling has fewer elements and results in a smaller solution matrix, so it requires less computer storage. This matrix is fully populated however, while the finite element matrix is mostly zeros, so solving the smaller matrix is at least as difficult for the computer as solving the larger finite element matrix. Figure 8[5] shows how easy it is to visualize the results of a boundary element model.

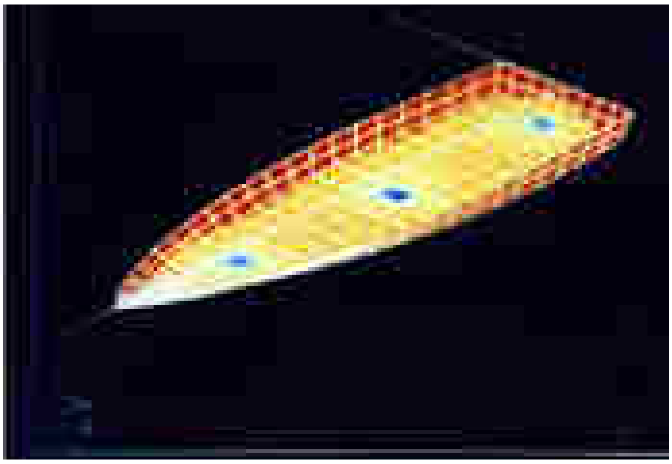


Figure 8 – Boundary Element Model Solution for a Boat Hull with Three Anodes.

The advantages of computer modeling are that the pictures of the results are usually colorful and pretty, entering the wrong boundary conditions will usually accurately predict the areas with the most and least protection even though it will get the amount of protection wrong [6], potential profiles can be visualized even in soil electrolytes, time dependency of the results can sometimes be modeled, given the right boundary conditions, and it is fairly easy to try multiple changes in geometry.

Disadvantages of computer modeling are that a lot of computing power is usually required, the software can be complicated to learn and use, accuracy of the boundary conditions at the surfaces are critical to getting the magnitude of the protection right, and modeling of flow is extremely difficult.

BOUNDARY CONDITIONS

Since boundary conditions, e.g. polarization curves, are critical for accurate modeling, especially computer modeling, it is important to get curves that are representative of the full sized structure. Polarization curves are usually developed by scanning the potential of a specimen of the appropriate material immersed in the appropriate electrolyte and measuring the resultant current density. Unfortunately, the current densities measured this way usually are reduced as scan rates are lowered and pre-exposure time before scanning increases[7][8][9].

The most accurate polarization curves for predicting long-term performance of a structure in seawater are generated over time periods similar to those that the structure will experience, i.e. months or even years. One method which has given good results is the use of long-term, potentiostatic polarization curves[10][11][12]. In this method, a specimen of the appropriate material is placed in the appropriate electrolyte and held at a constant potential while the current is measured. Once the current stabilizes, which in seawater can take several months, that current is noted. A different specimen is held at a different potential and its stable current is measured. In this way, each specimen generates a potential-current pair that can be plotted and, by connecting the dots, a polarization curve is formed. The resultant long term, potentiostatic polarization curve is a good representation of the long-term performance of the structure, but will not be good at predicting short term behavior or transients.

FLOW EFFECTS

Current densities usually rise with increasing electrolyte flow across the surfaces. Even stopping and re-starting flow can have dramatic effects on current density, as shown in Figure 9[13].

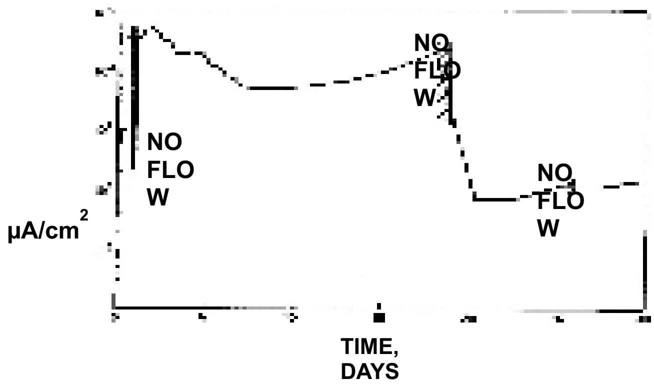


Figure 9 – Effect of Intermittent flow on Current Density

Even if measuring the effect of flow accurately is possible, scaling this effect is extremely difficult and depends on how the flow affects the reactions occurring. If the reaction rates are controlled by diffusion of something through the electrolyte, for example dissolved oxygen diffusing towards cathodically-protected surfaces to react to form hydroxide, then the reaction rate will vary with diffusion boundary-layer thickness. If the reactions are controlled by diffusion through a corrosion product or scale, such as through a calcareous deposit, then the reaction rate will vary little with flow but will vary with film thickness, which itself may vary in its formation rate with flow. Reactions controlled by physical transport to the surface, such as erosion-corrosion, will vary with the amount of turbulence. Some reactions that are controlled by barrier films, such as the corrosion of copper-based alloys, will not be much affected by flow until a specific surface shear stress is reached that removes the film. Apparent polarization behavior could be affected by any of multiple hydrodynamic parameters and since each of these parameters scales differently with increasing flow velocity, the effects of flow on polarization curves are nearly impossible to predict or to scale properly. For example, shear stress at the wall of a pipe increases as the velocity, v, to a power, v0.8. Mass transport scales as v1.8. For a rotating cylinder electrode shear stress varies as v0.7 and mass transport, assuming turbulent conditions, scales as v1.7. For a rotating disk, both scale as v0.5.

To summarize, polarization resistance is usually not linear with potential, may not even be single-valued, and may be a function of the environment, material, flow, total current passed, time, scan rate, and pre-exposure time. Long-term potentiostatic polarization curves work well for seawater predictions if surface blocked by hard fouling is accounted for[6].

EDGE EFFECTS

Sometimes the polarization behavior on edges is different from that on the rest of the surface. For example, on painted parts, paint will typically draw away from outside edges, leaving a thinner coating than on the rest of the surface, and accumulate on inside edges. Electroplated coatings have the reverse effect, being thicker on outside edges than elsewhere.

To understand how edges scale, a full size panel 100 cm on a side is assumed to have an edge effect that extends 1 cm from all edges. This full size panel therefore has an edge-affected area of ~400 cm2, leaving the remaining surface of 9600 cm2 unaffected by the edges. This gives an edge-to-non-edge ratio of 400/9600, or 0.42. If a 1:10 scale model of this panel is created, it will be 10 cm on a side. With the same 1 cm wide edge effect, 40 cm2 of edge will be affected, while the remaining 60 cm2 will not. This gives an edge-to-non-edge ratio of 40/60, or 0.67. Therefore, the scale model will have almost twice the effect of edges as the full size structure. For large structures with simple geometries that have few edges, this effect is negligible, but for structures that have many edges such as those made from multiple thin beams, the edge effect must be considered in the modeling process.

QUALITATIVE MODELING

Sometimes in modeling all that is needed is a qualitative assessment of how uniform the protection will be over the structure. If the protection is uniform, then design of the system is fairly easy. One method of determining qualitatively how uniform current distribution will be is my using the Wagner Number, W, which is the ratio of polarization resistance to electrolyte resistance[14]. Higher values of W indicate that the current will be spread over longer distances, making it more uniform. Figure 10 shows how W can be used to qualitatively predict behavior of a galvanic couple, and Figure 11 shows how W can be used for a tube-in-plate heat exchanger where the tube is the anode.

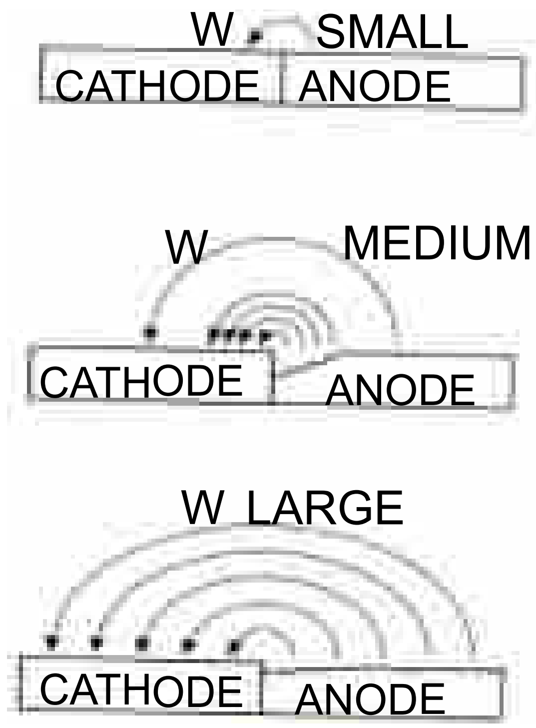


Figure 10 – Using the Wagner Number to Qualitatively Predict the Behavior of a Galvanic Couple

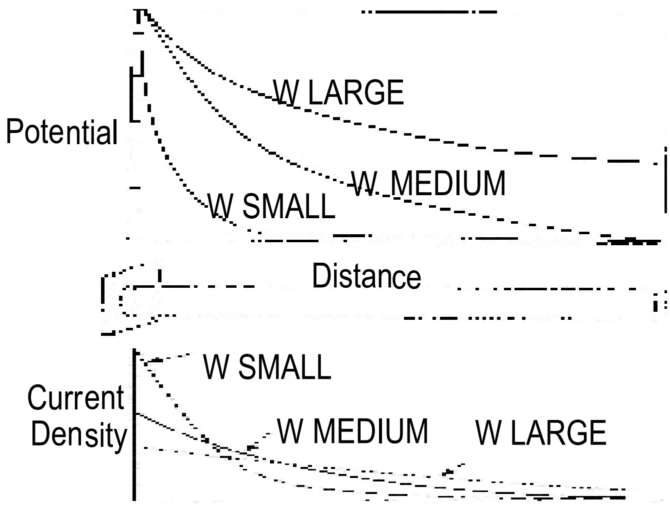


Figure 11 – Using the Wagner Number to Qualitatively Predict the Behavior of a Tube-In-Plate Heat Exchanger

ACKNOWLEDGEMENTS

The author wishes to acknowledge the various individuals whose ideas or research were quoted in this paper. They include John Scully, Robert Guanti, Robert Janeczko and Virginia DeGiorgi.

REFERENCES

1. Hack, Harvey P. "A Review of Finite Element and Boundary Element Corrosion Modeling at the Naval Surface Warfare Center," Corrosion Reviews, Vol. 15, Nos. 1-2, pp 195-209, 1997.
2. Hack, Harvey P. "Scale Modeling for Corrosion Studies," Corrosion, Vol. 45, No. 7, pp 601-606, 1989.
3. DeGiorgi, V. G. and Kaznoff, A. I., "Computational Simulation Techniques as Assets in Infrastructure Corrosion Control," Corrosion Forms and Control for Infrastructure, Victor Chaker (ed.), ASTM STP 1137, ASTM International, West Conshohocken, PA, 1992.
4. DeGiorgi, V. G., Thomas, E. D. II, and Kaznoff, A. I., "Numerical Simulation of Impressed Current Cathodic Protection (ICCP) Systems Using Boundary Element Models," Computer Modeling for Corrosion, ASTM STP 1154, ASTM International, West Conshohocken, PA, 1991.
5. Trevelyan, J. and Hack, H. P., "Analysis of Stray Current Corrosion Problems Using the Boundary Element Method," Boundary Element Technology IX, C. A. Brebbia and A. J Kassab (eds.), Computational Mechanics Publications, Ashurst, Southampton, UK, 1994.
6. Hack, H. P. and Janeczko, R. M., "Verification of the Boundary Element Modeling Technique for Cathodic Protection of Large Ship Structures," Proceedings of the 1994 Tri-Service Corrosion Conference, 1994.
7. Scully, J. R., Hack, H. P., and Tipton, D. G., "Effect of Exposure Time on the Polarization Behavior of Marine Alloys Under Flowing and Quiescent Conditions," Corrosion, Vol. 42, No. 8, pp 462-469, NACE International, Houston, TX, 1986.
8. Hack, H. P. and Scully, J. R., "Galvanic Corrosion Prediction Using Long- and Short-Term Polarization Curves," Corrosion, Vol. 42, No. 8, pp. 462-469, NACE International, Houston, TX, 1986.
9. Hack, Harvey P., "Exposure Time Effects on Current Densities of Polarized Marine Materials," Paper 210, Corrosion/83, NACE International, Houston, TX, 1983
10. Hack, Harvey P., "Galvanic Corrosion Prediction Using Long-Term Potentiostatic Polarization Curves," Paper 73, Corrosion/83, NACE International, Houston, TX, 1983.
11. Scully, J. R. and Hack, H. P., "Galvanic Corrosion Prediction Using Long-Term and Short Term Potentiostatic Polarization Curves," Paper 34, Corrosion/84, NACE International, Houston, TX, 1984.
12. Hack, Harvey P., "Atlas of Polarization Curves for Naval Materials in Seawater," Report CARDIVNSWC-TR-61-94/44, United States Naval Surface Warfare Center, Carderock, MD, 1995.
13. Hack, Harvey P. and Guanti, Robert J., "Effect of High Flow on Calcareous Deposits and Cathodic Protection Current Density," Materials Performance, Vol. 28, No. 3, pp. 29-35, NACE International, Houston, TX, March 1989.
14. Scully, John R., and Hack, Harvey P. "Prediction of Tube-Tubesheet Galvanic Corrosion Using Finite Element and Wagner Number Analysis," Galvanic Corrosion, H. P. Hack (ed.), ASTM STP 978, ASTM International, West Conshohocken, PA, pp. 136-157, 1988.

The paper had been presented in CORCON 2014.

A Report on One day workshop on Condition Monitoring, Health Assessment & Rehabilitation of Concrete Bridges & Buildings

NACE International Gateway India Section (NIGIS) in association with City and Industrial Development Corporation (CIDCO), Navi Mumbai jointly organised by a one day Workshop on Condition Monitoring, Health Assessment & Rehabilitation of Concrete Bridges & Buildings at CIDCO Bhavan, Navi Mumbai on 6 July 2019.

This interactive workshop is necessary due to the rapid deterioration of exiting bridge structures continues to remain a serious threat in engineering, environmental, economic and structural areas for focus on rehabilitation.

The workshop was inaugurated in the presence of Dr. Kamachi Mudali, Chairman, NIGIS and Mr. N Mahohar Rao-Trustee, Denzil D'costa-Treasurer, Sumeet Kataria-Secretary, Rishikesh Mishra-Manager, Technical Services. Dr. U Kamachi Mudali started the session by addressing about the activities of NACE International such as Corrosion mitigation training programs and annual conference & Expo CORCON 2019: 23-26 September 2019, followed by a brief on Corrosion and its relevance to the Bridges and Infrastructure concerning CIDCO.

The topics covered during the workshop are Corrosion mechanisms in conventional and pretensioned concrete structures & Specifications for grouts and grouting procedures for PT buildings & bridges by Dr. Radhakrishna G. Pillai, IIT Madras, Structural and corrosion issues in post-tensioned (PT) concrete structures by Mr. Vinay Gupta, Tandon Consultants, Performance based specifications for durable concrete structures & Maintenance and condition assessment of buildings by Prof. Manu Santhanam, IIT Madras, Principles and case studies on cathodic prevention and protection of concrete buildings and bridges by Mr. Dhruvesh Shah, Vector Corrosion Technologies and and Field issues and way forward in concrete bridge design & construction by Mr. P. G. Venkatram, L&T Infrastructure Engg. Ltd.

The Program was attended by 20 CIDCO personnel Rajesh Thasale, Swing Tirpude, Asawari Kale, Megaboob Mulani, Rajendra Rade, Tayaji Ahire, Anurag Bhoir, Santosh Ombhase, Nilesh Shahapurkar, Praffull Deore, Sanjay Pudale, Vilas Bankar, Sunil Deore, Karuna Pillai, Sonali Sawant, Milind Bangaonkar, Avinash Patil, Digvijay Khanvilkar, , D P Thombare and Arjun Koparkar and the same was well received, and a note of appreciation was given by Mr. Santosh Ombhase followed by the vote of thanks appreciating the CIDCO team to be available on a holiday and giving full support to the session.

NIGIS agreed to conduct more such programs in future for CIDCO of Corrosion mitigation and prevention.

On behalf of NIGIS CIDCO felicitating
Mr. P.G. Venkatran

NIGIS Team and CIDCO participants during the program

Report on Advanced Training Program on Water Treatments Programs

Water is very important for human being and other living things. Water covers 70% of the Earth's surface, mostly in seas and oceans and only approx. 3% is considered fresh water. Water is not only essential for human body, it also play an important role in our daily life activities. For more availability of purified water, Water treatment can be very helpful for the society today because they are saving the lives of many human beings by removing contaminants from water.

To fulfil the mission of NACE International to protect people, assets and the environment from the adverse effects of corrosion, NACE International Gateway India Section (NIGIS) has taken initiative in this regard and organised Advanced Training and Educational Program on "Cooling Water Treatments (CWT) Program, Boiler Water Conditioning, Reverse Osmosis Technologies for Treatments for Various Applications and Optimisation of Operating Costs & Water Conservation" during the period 6-7 November, 2019 at Hotel Park Inn, New Delhi.

The Objective of the training programme covers various aspects like to impart knowledge on Fundamentals of Water Chemistry applicable to RWTP, Cooling Water Treatments, DM Plants, Boiler water conditioning and Ultra filtration-Reverse Osmosis-membranes, Modern Trend in CWT program & to create awareness about cooling water side corrosion, fouling problems & control measures, increasing life of coolers / condensers on CW side, To create awareness about Boiler water side Problems, control measures & about Condensate Corrosion & control measures and Condensate Polishing Units, Modern Trends in Treatments Program for BWT & RO Technologies, To Acquaint with design & operation, Practical Applications and Case Studies etc.

The faculty for this course was Mr. G L Rajani, Technical Consultant having wide professional practical experience in water treatment and the program had been coordinated by Mr Rishikesh Mishra, Manager - Technical Services, NIGIS.

The participants were from Karnataka Engineering Enterprises, Lalitpur Power Generation Company Limited, Ensavior Technologies Pvt. Ltd, Indian Oil Corporation Ltd, BPCL - Kochi Refinery, Reliance Industries Limited, Oil and Natural Gas Corporation Ltd., HPCL-Mittal Energy Ltd., (HMEL), SUEZ, Infra13 Pvt. Ltd., Surya Corporation, GAIL India Limited, MojjEngg Systems Ltd., Ion Exchange (India) Ltd., Vasu Chemicals LLP, Engineers India Limited, Ti-Anode Fabricators Pvt Ltd.

The training program ended with receiving high end appreciation from the participants.

Participants at Advanced Training Program on Water Treatment Program

A Report – Technical talk at IIT Bombay organised by NACE International, India Student Chapter

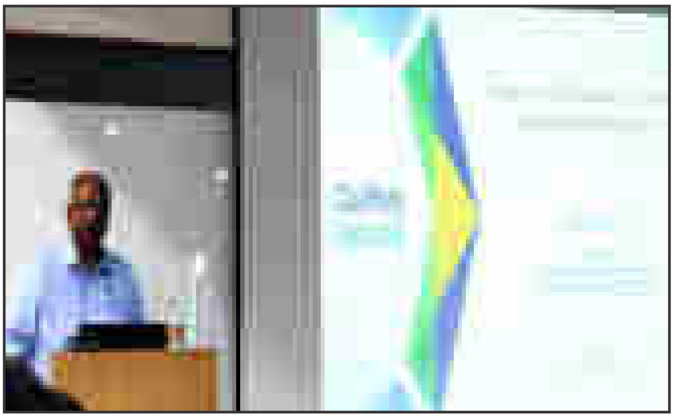
NACE International, India Student Chapter had organised two technical talks in association with Dept. of Metallurgical Engineering and Materials Science - IITB, NACE International Gateway India Section, Indian Institute of Metals, Mumbai Chapter and ASM International, India Section at IIT Bombay, Mumbai.

The first invited talk was delivered on "A New Paradigm for Designing Corrosion Resistant Materials" delivered by Professor Gerald S. Frankel, on December 13, 2019. Dr. Frankel is the Distinguished Professor of Engineering, Professor of Materials Science and Engineering, and Director of the Fontana Corrosion Center at the Ohio State University. In his talk he explained "Corrosion, the environmental degradation of materials, is a complex process that depends on details of the material and the environment. Metals, glasses and ceramics all undergo corrosion processes, and predicting the degradation of all three of these material classes is important for the design of a mined geological nuclear waste repository that should prevent the release of dangerous radionuclides for a performance period of >105 y".

The second talk was delivered by Professor Vilupanur A. Ravi, Chair, Chemical and Materials Engineering Department, California State Polytechnic University, Pomona, CA on December 19, 2019. In his talk "Engineered Coatings Using Pack Cementation Processes" he explained that high temperature degradation of metallic materials occur by different mechanisms, e.g., oxidation in air, accelerated corrosion under fused salt films ("hot corrosion"), etc. Two broad approaches are available to combat these problems: (a) alloy design, and (b) protective coatings/surface modification.

Both of the dignitaries had visited the Gateway India Section office on the invitation of Dr. U Kamachi Mudali, Chairman, NIGIS and discussed the Corrosion Scenario of India and shown their interest to participate in the future CORCON conference and appreciated the effort of NIGIS towards spreading corrosion awareness by dissemination of knowledge regarding corrosion, its protection and control, in India and worldwide.

Prof. Gerald S. Frankel giving the technical talk at IIT Bombay



Prof. Vilupanur A. Ravi giving the technical talk at IIT Bombay

Dr. U Kamachi Mudali felicitating Prof. Frankel at NIGIS office

Dr. U Kamachi Mudali felicitating Prof. Ravi at NIGIS office

A Report – NIGIS FOUNDATION DAY 2019

Foundation Day is an important milestone for each organization, where we show our gratitude for the wisdom, courage and commitment demonstrated by those who contributed to the establishment of the Section. NACE International Gateway India Section (NIGIS) has celebrated FOUNDATION DAY on 23rd August 2019 at The Acres Club Chembur Mumbai.

The session started with Dr. U. Kamachi Mudali, Chairman NIGIS welcoming Prof G D Yadav, Chief Guest with a bouquet of flowers, followed by The Trustee Mr. N Manohar Rao, Vice Chairman Mr. Dipen Jhaveri, Past President Mr. Tushar Jhaveri, Treasurer Mr. Denzil D'Costa, and the Secretary Mr. Sumeet Kataria occupying the Dias. Mr. Dipen Jhaveri welcomed all to the Foundation Day and mentioned that the NIGIS foundation day not only provides an opportunity to celebrate, but to recall the evolution of NIGIS and reflect on the past activities and initiatives undertaken by NIGIS.

Mr. Sumeet Kataria submitted the report on achievements made by the section in the last year. In his brief speech he updated members about CORCON conference, NIGIS Awards and Training program .

Then the Chairman Dr. U Kamachi Mudali briefed the members about the CORCON-2019 and requested all to participate and share their knowledge & expertise in the conference. He also introduced his NIGIS Executive committee members Dr. Anil Bhardwaj, Dr. V S Raja, K B Singh, Dr. Buddhadeb Duari, Ashish Khera, Mahesh Aradhye, Dr. Rani P. George, Sandeep Vyas, Dr. C. Kannan, Dr. Deepashri Nage, Dr. D. Parvatalu, Dr. N.Rajendran, Dr. S Parida, Dr. SupratikRoy Chowdhary, Dr. Prabhakar Rao, Niraj Kumar, C V Manian, Amrit Rekhi, Ajay Popat, Dr. Radha Krishna Pillai, Dr. R Venkatesan, Representative- South Zone and Mr. S Ravichandran, Representative - East Zone.

Chief Guest Prof G D Yadav mentioned that NIGIS activities are the need of the hour and NIGIS cause to support the mission of Corrosion is well appreciated. He gave the members an insight of the various initiatives being taken by his organization, ICT, towards holistic development of young engineers today. The Chairman then felicitated Prof G D Yadav with a Memento and Souvenir.

Mr. Manohar Rao addressed the gathering and mentioned that the Board was working closely with the industry and proposed list of trainings and events that are to be taken in the next year. He also introduced Mr. P K Taneja, Ex E D of ONGC who shall take as ED of NIGIS and help further step up the operations and take NIGIS to greater heights.

Mr. Denzil D'Costa delivered the vote of thanks and requested all to join for the Dinner.

Dr. U Kamachi Mudali welcoming the delegates

Dr. U Kamachi Mudali felicitating Prof G D Yadav

SGB members and Distinguished Guests on the Dias

N Manohar Rao briefing the NIGIS future activities

Report – NIGIS first overseas Training Program on Fundamentals of Coatings Lining at Srilanka

NACE International Gateway India Section (NIGIS) organized 1st time in overseas educational & training program on "Fundamentals of Coatings Lining" on 17 Oct – 18 Oct 2019 for Colombo Dockyard PLC, Colombo, Sri Lanka. NIGIS educational program provide an excellent opportunity for exchange of knowledge and information on matters concerning corrosion problems and solutions through the training programs.

The inaugural function started with a welcome address by Mr. D A S Nishantha Fernando, (Asst. Prod., Manager-Hull Treatment), Colombo Dockyard PLC.

The Program was inaugurated by Mr. S G Senadeera, General Manager (Ship Repair Prod.), Colombo Dockyard PLC. In his inaugural address he appreciated the efforts of Team members of NIGIS for providing educational training program to his officers.

Mr. Denzil Dcosta, Sr. Manager, Graco - Program Coordinator, faculty member highlighted various aspect on Fundamentals of Coating & Lining. He also informed that program specially made for properly understand the technical aspects of surface preparation and application of a protective coatings system on a variety of structures for the industries. The program is benefited to Engineer, Quality Control (QA/QC Personnel), Production, Technician, Supervisor, Painter, Blaster, User, Fabricator, Foremen & Paint Contractors. It is designed to give the participant a path for continued professional development and more job opportunities in paints and coatings industries.

Mr. K V Badri Narayan, Technical Services Manager, Akzo Nobel - faculty member had said that the program is benefits to all the participants belong to paints & coating industries. The program aware and enhance the knowledge of PSPC complied ballast water tanks surface preparation & coating requirements/procedures and repair, construction, maintenance and quality control.

Mr. Manoj Mishra, Manager Admin NIGIS in his brief speech, expressed his commitment to organize the educational & training program in Colombo Dockyard, Sri Lanka. He also informed about NIGIS activities i.e. annual Corrosion Conference & Exhibition (CORCON) and educational programs. He also requested to participate in CORROSION -2020, Houston, USA and as well as in CORCON-2020, Chennai, India.

Mr. P S Abeysinghe, Asst. General Manger (Ship Repair Prod.), Colombo Dockyard PLC has appreciated to all team members of Colombo Dockyard and NIGIS to organize this program and also he distributed the participation certificate with NIGIS (WFT Gauge and Shirt) to all the participants and in last day of program. Mr. Ositha Ilanganthilake, Engineer, SOF proposed the vote of thanks.

Group Photo - Fundamentals of Coating Lining in Colombo Dockyard PLC, Colombo, Sri Lanka

A Report - Corrosion Management on Protective Coating and Cathodic Protection Systems on 14th Dec 2019

NACE International Gateway India Section (NIGIS) based on the Round Table Conference held at CORCON 2019, has successfully conducted the first program on Corrosion Management on Protective Coating and Cathodic Protection Systems on 14th Dec 2019 at Kolkata, West Bengal. Thirty nine, Professional Engineers from various industries participated. The program provided an excellent platform for interaction on matters concerning corrosion problems and solutions.

The program was initiated by Mr. N Manohar Rao, Trustee NIGIS, who delivered the welcome address and briefed on NIGIS activities. Mr Rao also felicitated the supporters of the program; Mr. Sanjay Chowdhury, Business Development, Berger Paints India Ltd, Mr. Vijay Sharma, CEO, Boekhoff Technocrates, Dr. B Duari, Managing Director, Lalita Infraprojects Pvt Ltd and Mr. Shaikh H Rashid, Technical Head, Himoya Corrosion Technology Pvt. Ltd.

The program keynote address was given by Mr. Sanjay Chowdhury and he mentioned that positive thought and firm commitment by every individual are required to address the corrosion issues as it is done to curb corruption in society and elaborated on the importance in implementation of corrosion combat practices with protective coatings.

Besides, invited lectures on Protective Coating by Mr. S Ravichandran, President-NIGIS East Zone, Mr. Denzil Dcosta, Treasurer NIGIS and invited lectures on Cathodic Protection Systems by two eminent speakers and NACE certified technologists Mr. Shaikh H Rashid and Mr. Kaushik Duari.

An open technical forum and discussions on various issues of Corrosion Management on Protective Coating and Cathodic Protection was addressed by the panel members and experts from industry Mr. Sanjay Chowdhury, Business Development, Berger Paints India Ltd, Dr. B Duari, Past President-NIGIS East Zone, Dr. Jayanta K Saha, GM, INSDAG, and Mr. N Manohar Rao-Trustee.

The program coordinators Mr. S Ravichandran and Mr. Manoj Mishra delivered the vote of Thanks. The well accepted content of the program and its response is paving way for the next event in East at Haldia- West Bengal. More such events are being planned for other parts of the country.

N. Manohar Rao felicitating Sanjay Chowdhury

Panel Members during technical forum discussions

Group Photo - Corrosion Management on Protective Coating and Cathodic Protection Systems

A Report – NIGIS office renovation & Shree Satyanarayan Puja

"NACE International Gateway India Section" existing office was renovated during the period Sept – Nov 2019.

Shree Satyanarayan Puja had been conducted in the office on 24 Nov 2019 (Sunday). Shree Satyanarayan Puja is a puja or worship which is dedicated to Lord Vishnu (the Preserver), one among the great Hindu trinities.

The word "Satyanarayan" is an amalgamation of two words, 'Satya' means truth, 'Narayan' means the highest and ultimate form of being or the supreme man; that means Lord Vishnu is the personification of the truth.

The Pooja was performed by the Section Chairman Dr. U Kamachi Mudali and Dr. Sivagami Mudali. The pooja well attended by the SGB members, NACE members and NIGIS staff.

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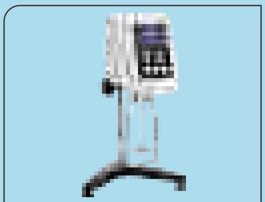
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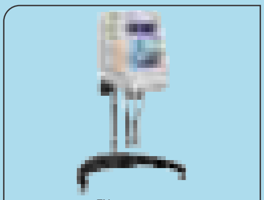
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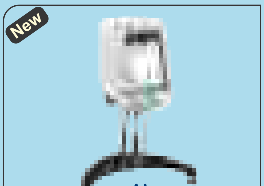
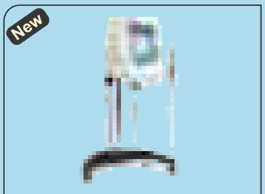
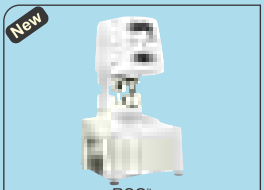


DVNext Rheometer

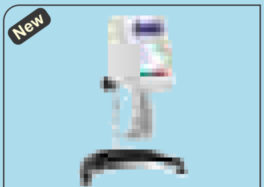
CTX Texture Analyzer



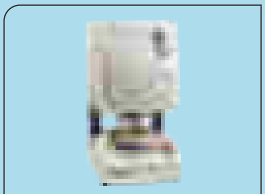
Gel Timer Instrument



RSO Oscillatory Rheometer



Wells Cone & Plate DV Next CP Viscometer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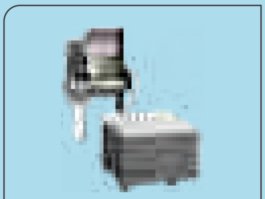
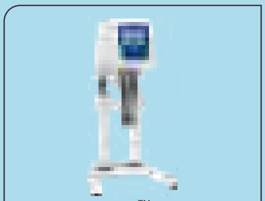
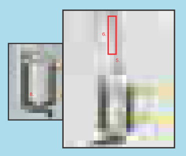

PVS Rheometers


RST-CPS Touch™ Rheometers


RST-SST Touch™ Rheometer


RST-CC Touch™ Rheometer


Viscosity Standards


Small Sample™ Adapter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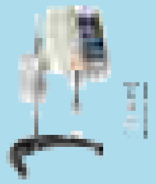
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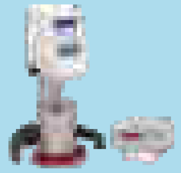
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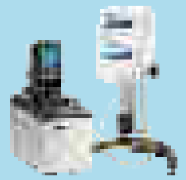
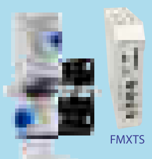
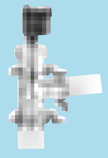
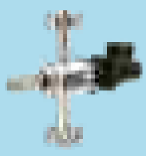

Circulating Temp. Bath

Process Viscometers (To measure in-line Viscosity)



FAST101/MXTS Viscosity Sensor/Transmitter


FAST-102
Compliant to 3A sanitary standards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