CHAIR OF MATERIALS PROTECTION
Faculty of Mechanical Engineering and Naval Architecture
Ivana Lučića 5, 10000 Zagreb, CROATIA
Tel./fax: +385 (0)1 6168 343
www.fsb.unizg.hr/korozija

PROFILE

The Chair of Materials Protection was founded in 1961, together with the Laboratory of Materials Protection. It is a part The Department of Welded Structures at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

The research activities carried out in the Chair are targeted at the study of complex corrosion phenomena which have not been fully explained and understood yet, such as localized corrosion processes in stainless steels and the methods for reducing the danger of corrosion damage. The Chair has been mostly involved in this type of research for the past decade, especially for the water environments containing chloride.
The research conducted as part of research projects includes:

- Corrosion phenomena in welded structures and other structures made of high alloyed steels and the methods for their elimination.
- Corrosion and protection of the structures made of high alloyed steels.
- Localized corrosion phenomena in stainless steels and the methods for their elimination.
- Corrosion protection by protective coatings.
- Corrosion inhibitors.

The above mentioned research as well as the experiences gained through numerous expertise jobs undertaken on various damaged structures made of stainless CrNi steel, that are applied in almost all industrial fields - for example, oil industry, pharmaceutics, chemical and food processing industry, water supply, shipbuilding, nautical sector, civil engineering, have resulted in new and valuable knowledge. Thus acquired knowledge is further transferred to the students. Since the validity of the research results has been proven in practice, this knowledge has also established the Chair as an authority on stainless steels both in Croatia and abroad. Another aspect of the Chair's cooperation with industry is its participation in the organization of continuous education of experts which is characterized by experience exchange and knowledge transfer. Today greater environmental awareness and more stringent regulations are required, especially with regard to corrosion protection technologies. Since shipbuilding is one of the pillars of the national economy, intensive research and professional development of the staff engaged in material protection in the area of shipbuilding and marine environment applications has been conducted for the several past years. The aim is to reduce protection technology costs and implement modern protection systems with minimized effects on the environment.
The Chair of Materials Protection has been cooperating with numerous similar departments and institutions worldwide. This allows for further professional development of the staff, experience exchange and carrying out specific research. Consequently, a number of well-known experts in the field of corrosion and protection have given lectures to the students and participants of specially organized seminars. Scientific and professional activities of the Chair have been confirmed by numerous contributions the experts of the Chair have made in

this field. However, a special emphasis should be placed on the works in the analysis of corrosion damage causes in stainless steel welds, included in Corrosion Atlas, a seminal work in the field.

RELEVANT EXPERIENCE

Bilateral China – Croatia scientific research project:

- "Self-healing coating for corrosion protection based on microcapsules / nano-particles", leader of the project: Asst. Prof. Ivan Stojanović, Ph.D., 2018 – 2020, financed by Ministry of science and education of the Republic of Croatia.

List of scientific research projects:

- Scientific project: "Corrosion phenomena in welded and other structures made from high alloyed steels and methods for their prevention", leader of the project: Prof. Ivan Juraga, Ph.D., 2006 – 2013, financed by Ministry of science and education of the Republic of Croatia.
- Scientific project: "Corrosion and Protection of structures made of high alloyed steels", leader of the project: Prof. Ivan Juraga, Ph.D., 2000 – 2004, financed by Ministry of science and education of the Republic of Croatia.
- Scientific project: "Localised corrosion phenomena of stainless steel and their prevention", leader of the project: Prof. Ivan Juraga, Ph. D., 1998 - 2000, financed by Ministry of science and education of the Republic of Croatia.

Information technologies project:

- "Case histories- Corrosion damages data bank", supported by the Ministry of Science, Education and Sports of Republic of Croatia.

List of main studies and expertise's for industry:

- Failure analysis and rehabilitation project on damaged armour grounding clamps on subsea power cables, HOPS d.o.o., 2016-2018.
- Quality control testing of paint system on electric motors, Končar – MES, 2018.
- Quality control testing of paint system, anode material and welded duplex stainless steel elements for MOSE project intended to protect the city of Venice, BRODOSPLIT, 2015-2017.
- Failure analysis of causes of corrosion damages on stainless steel equipment in food industry, SINITECH, 2015.
- Quality control testing of paint system on mine clearance system, DOK-ING, 2015.
- Failure analysis of causes of corrosion damages on stainless steel W.Nr. 1.4571 pipelines for water installed in underground parking garage in Düsseldorf, 2014.
- Failure analysis of corrosion damages on pipes made from ferritic stainless steel, PIREKO, 2014.
- Failure analysis of corrosion damages on nonmagnetic high alloyed stainless steel tubes for oil drilling, CROSCO, 2013.
- Technology research and transfer project - Surface treatment technology's for stainless steel welded structures, MIAB, 2009 – 2013.
- Testing's and Expert opinion about the passivity of ship tanks made from duplex stainless steel, SHIPYARD 3. MAJ, 2011.
- Establishing the causes of corrosion damages on stainless steel tanks for soap

production, 2009.

- Establishing the causes of corrosion damages on stainless steel pipelines in water treatment plant, preliminary design of repair, material selection, technical assistance, Ponikve, 2005-2007.
- Investigation of causes of corrosion damages on stainless steel pipes for oil industry, INA, 2007.
- Establishing the causes of corrosion damages on stainless steel water tanks installed on firefighting vehicles in China, Ziegler, 2006.
- Testing's of corrosion resistance of welded joints made from Hastalloy C22 and stainless steel W.Nr. 1.4571 – pitting corrosion resistance, resistance towards intergranular corrosion, stress corrosion resistance, 2006.

BRIEF DESCRIPTION OF THE KEY PERSONNEL

Vesna Alar was born on 24 December 1966. She graduated at the Faculty of Chemical Engineering and Technology University of Zagreb in 1991. Since 1991 she has been working at the Department of Materials of the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. In 1994 she acquired the Master `s degree at the Faculty of Chemical Engineering and Technology and the Doctor's degree in 2000 at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb. The scientific work includes research in the field of corrosion and protection of metals. She is a Head of the Chair of Materials Protection.

Vinko Šimunović was born on 7 November 1970 in Zagreb. He graduated from the University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture in 1999. Since 2000 he has been working as assistant at the Chair of Materials Protection at the Faculty of Mechanical Engineering in Zagreb. He is a researcher in the field of corrosion resistance of stainless steels and in 2012. he defended his PhD thesis on topic "Microbiologically influenced corrosion of stainless steel welded joints in water". The scientific work includes research in the field of corrosion and corrosion protection. He is a Head of the Laboratory of Materials Protection.

Ivan Stojanović was born on 9 June 1979 in Pula, where he finished elementary and secondary technical school. He graduated Marine Machinery at the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb in 2003. Since 2004 he has been working as researcher at the Chair of Materials Protection at the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb. In January 2011, he successfully defended his Ph.D. thesis on the topic "Influence of Technological Parameters on Corrosion Protection Properties of Waterborne Coatings". The scientific work includes research in the field of corrosion and protection methods.

Marin Kurtela was born on 3 December 1981 in Zagreb. He finished elementary and high school in Dubrovnik and graduated Aerospace Engineering at the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb in 2010. In 2011. he has become postgraduate student and since 2016. he has been working as researcher at the Chair of Materials Protection at the same Faculty. From 2010 to 2014 he worked as hydraulics specialist (Hydro Power Plants) at Brodarski institute Ltd., and last two years he

has been working as CAD and Hydraulics Designer (Yacht Equipment) at private company (TE-Marine Ltd.).

RELEVANT PUBLICATIONS

1. Stojanović, Ivan; Šimunović, Vinko; Alar, Vesna; Kapor, Frankica. Experimental Evaluation of Polyester and Epoxy– Polyester Powder Coatings in Aggressive Media. // Coatings. 8 (2018) , 98; 1-12
2. Alar, Vesna; Žmak, Irena; Stojanović, Ivan; Šimunović, Vinko; Čeralinac, Zoran. Abrasion and erosion wear of electrodeposited nickel – silicon carbide nanocomposite coatings = Abrasiv- und Erosionsverschleiß von galvanisch Nickel-Siliciumkarbid Nanokomposit-Beschichtungen. // Materialwissenschaft und Werkstofftechnik. 48 (2017) , 8; 785-791
3. Alar, Željko; Alar, Vesna; Aleksandrov Fabijanić, Tamara. Electrochemical Corrosion Behavior of Near-Nano and Nanostructured WC-Co Cemented Carbides. // Metals. 7 (2017) , 3; 69-1-69
4. Đukić, Ankica; Alar, Vesna; Firak, Mihajlo. Corrosion behaviour of the nickel based materials in an alkaline solution for hydrogen evolution. // Indian journal of chemical technology. 24 (2017) , 1; 88-92
5. Jakovljević, Suzana; Alar, Vesna; Ivanković, Antonio. Electrochemical Behaviour of PACVD TiN-Coated CoCrMo Medical Alloy. // Metals. 7 (2017) , 7; 231-245
6. Alar, Vesna; Žmak, Irena; Runje, Biserka; Horvatić, Amalija. Development of Models for Prediction of Corrosion and Pitting Potential on AISI 304 Stainless Steel in Different Environmental Conditions. // International Journal of Electrochemical Science. 11 (2016) ; 7674-7689
7. Vrsalović, Ladislav; Paić, Tomislav; Alar, Vesna; Stojanović, Ivan; Jakovljević, Suzana; Gudić, Senka; Smoljko, Ivana. The effects of surface treatment AISI 316L welded joints on its corrosion behaviour in chloride solution. // Kovové materiály. 54 (2016) ; 211-215
8. Ivušić, Franjo; Lahodny-Šarc, Olga; Otmačić Ćurković, Helena; Alar, Vesna. Synergistic inhibition of carbon steel corrosion in seawater by cerium chloride and sodium gluconate. // Corrosion science. 98 (2015) ; 88-97
9. Alar, Vesna; Stojanović, Ivan; Šimunović, Vinko; Novak, Tomislav. Crevice corrosion resistance of high alloyed materials in 3.5 % NaCl solution. // International journal of materials research. 105 (2014) , 6; 603-606
10. Glogović, Zlatko; Kožuh, Zoran; Kralj, Slobodan; Alar, Vesna; Stojanović, Ivan. Properties of aluminium coatings produced using manual and robotized flame spraying processes. // International journal of materials research. 105 (2014) , 2; 215-219
11. Stojanović, Ivan; Juraga, Ivan; Alar, Vesna. Influence of drying temperature on protective properties of waterborne and solventborne epoxy coatings. // International journal of electrochemical science. 9 (2014) , 5; 2507-2517
12. Juraga, Ivan; Stojanović, Ivan; Ljubenkov, Boris. Experimental research of the duplex stainless steel welds in shipbuilding. // Shipbuilding. 65 (2014) , 2; 73-85
13. Đukić, Ankica; Alar, Vesna; Firak, Mihajlo; Jakovljević, Suzana. A significant improvement in material of foam. // Journal of alloys and compounds. 573 (2013) ; 128-132
14. Alar, Vesna; Alar, Željko; Jakovljević, Suzana; Runje, Biserka. Influence of thermal and

electrochemical oxidation on the mechanical and corrosion properties of titanium alloy. // Kovové materiály. 51 (2013) , 4; 251-256

15. Alar, Vesna; Stojanović, Ivan; Židov, Bruno; Ivušić, Franjo. Corrosion resistance of high alloyed materials in 3.5% NaCl solution at elevated temperature. // International Journal of Electrochemical Science. 8 (2013) , 12; 12476-12486
16. Brajković, Tomislav; Juraga, Ivan; Šimunović, Vinko. Influence of surface treatment on corrosion resistance of Cr-Ni steel. // Engineering review. 33 (2013) , 2; 129-134

In the third edition of the book "Corrosion Atlas" published by Elsevier Science Publishers, Professor Juraga (former Head of the Chair of Materials Protection, retired professor) has published 3 case history failure investigations related to corrosion damages on stainless steel welded structures, performed on the Chair of Materials Protection.

DESCRIPTION OF THE MAJOR INFRASTRUCTURES AND EQUIPMENT

The Laboratory has been significantly upgraded through the acquisition of new testing equipment, such as a chamber for testing in salt atmosphere, a humidity chamber, a UV chamber, a device for alternating submerging and stations for electrochemical corrosion testing. This equipment allows for a wide range of corrosion testing and enhances the characterization of corrosion processes.

- Potentiostat/Galvanostat **VersaSTAT 3** – modern electrochemical techniques used in corrosion applications include Linear Polarization Resistance (LPR), Electrochemical Impedance Spectroscopy (EIS), and EIS at various polarization levels. Research of corrosion processes on metal-electrolyte interface and determination of the kinetics of electron transfer between the metal and the electrolyte anions.
- Potentiostat/Galvanostat **Model 273A** - various electrochemical corrosion measurement techniques such as potentiodynamic polarization, Tafel plots, polarization resistance, cyclic polarization, potentiostatic, galvanostatic, and galvanic corrosion studies, and open circuit vs. time measurements.
- Stereomicroscope Leica MZ6 – surface analysis, material characterization
- Corrosion testing in artificial atmospheres - Testing of structural materials and protection coatings in salt fog and humidity chamber
- Erichsen UV Test Chamber Solarbox 1500e – UV testing resistance
- Device for alternating submerging – simulation of alternate wet-dry condition such as splash zone
- Testing equipment for protective coating properties - thickness measurements, cross-cut adhesion, pull-off adhesion, impact, gloss, hardness and other properties of all types of protective coatings
- Testing of corrosion resistance of structural materials
    - Testing of resistance to pitting corrosion
    - Testing of resistance to intergranular corrosion
    - Testing of resistance to stress corrosion
    - Testing of resistance to crevice corrosion
- Passi Test Plus - testing of surface passivation on stainless steels, measures the open-circuit potential and the nobility of a metal (and consequently its resistance to corrosion).
- Olympus X-ray Fluorescence (XRF) analyser - provide qualitative and quantitative material characterization for detection, identification, analysis, quality control, process control, regulatory compliance, and screening, for metals and alloys, mining

and geology, scrap and recycling, environmental and consumer safety, education and research, and general manufacturing.

- Cathodic disbondment testing equipment - assessing the resistance to disbondment of damage to the coatings when exposed to cathodic polarisation.
- Electrochemical testing equipment for galvanic anode materials quality control – galvanic anodes for cathodic protection.