INSTITUTE OF CORROSION

MARINE CORROSION FORUM

FOR ALL WET CORROSION ISSUES

Welcome to MCF – Marine Corrosion Forum / ICorr – Institute of Corrosion (ABZ), 2021 April Webinars.

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Institute of Corrosion (ABZ) and MCF partnering with:

- COMSOL
- 28th April 2021

INSTITUTE OF CORROSION

“Modelling Corrosion and Corrosion Protection”

COMSOL – Ross Hubble

28th April 2021

About Us

- Most corrosion occurs due to electrochemical reaction processes taking place underwater and in wet or humid environments. Modelling corrosion allows engineers and scientists to investigate these processes, gain an understanding of the extent to which corrosion could occur over the lifetime of a structure and implement preventative measures to inhibit electrochemical corrosion, in order to protect their structures. In this presentation, we will discuss some of the benefits of corrosion modelling and what kind of simulations can be performed.
- We will start out with a brief introduction to corrosion simulations and how the theory can be applied to a simulation in the COMSOL Multiphysics® software. After the introduction, we will show a couple of examples within corrosion and corrosion protection.
- Ross works as an Applications Engineer at COMSOL UK. He graduated from the University of Cambridge in 2010 with a MEng in Chemical Engineering and then carried out his PhD investigating carbon oxide hydrogenation reactions.

Ross Hubble | Applications Engineer | COMSOL

Q&A

- Selection of Questions to **COMSOL**,
  Post-Presentation 28/04/2021

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2021

- Q1. Corrosion Software works on any specific models, can it support for corrosion process fluids having H2S, CO2, Amines, etc. With different concentrations?

- A1. To define the electrochemical reactions, the electrochemical properties, e.g. exchange current density, equilibrium electrode potential, are required as inputs. Different types of chemicals can be defined within the software, requiring the transport properties and stoichiometries of the reactions as inputs. We have a number of predefined examples for different processes. The CO2 corrosion example shows how the presence of CO2 in the process fluid can influence the corrosion rate: https://www.comsol.com/model/carbon-dioxide-corrosion-in-steel-pipes-17255

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- Q2. Can we use for designing equipment and piping or this is Lab Material Corrosion Rate evaluation software?

- A2. Once a model has been developed to simulate the rates of corrosion for a given geometry and material, the material of interest can be switched to see how this influences the behaviour. A Material Sweep study can enable the easy switching of material properties, allowing a study to be repeated for multiple different materials.

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- Q3. Can we study coating corrosion effects on UG piping?

- A3. It is possible to examine the influence of coating on corrosion processes as well as to also define species deposition if a material deposits on a structure and add film resistances. The ship hull Application Gallery examples demonstrates how coatings can affect corrosion:
- https://www.comsol.com/model/corrosion-protection-of-a-ship-hull-14565

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- Q4. Can Comsol use to describe the corrosion in Nuclear reactor under supercritical water conditions?

- A4. It may be possible in a simplified form, considering all factors may be difficult. COMSOL provides means to evaluate the potential and current distribution within an electrolyte/electrode using the current distribution interfaces, if the rates of electrochemical reaction are available.

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- Q5. I would like to ask how to simulate interference phenomena in Comsol? For example, a fixed offshore platform whose cathodic protection system interferes with a buried pipeline which is near to the ICCP anodic system (installed on the seabed), what would be the boundary conditions methodology and physics to use?

- A5. Yes, there is an example model for modelling stray current in our Application Gallery: https://www.comsol.com/model/stray-current-pipeline-corrosion-54761

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- Q6. Can we use this software for ICÇP System in Rebar concrete construction?

- A6. Yes, this is possible. There is an example rebar corrosion in concrete in our Application Gallery: https://www.comsol.com/model/cathodic-protection-of-steel-in-reinforced-concrete-11106

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- Q7. During your galvanized nail example, you only seemed to obtain a very small change in oxygen reduction current density when you moved from Tafel (activation) control to diffusion control (in wood). This conflicts with diffusion control in other environments (e.g.) seawater. Have I got this wrong?

- A7. In the example, the oxygen concentration does not change to a large degree, so the rate of transport is not a significant limit in this case. The combination of a transport interface with the secondary current distribution interface or the use of the tertiary current distribution interface both allow for the consideration of concentration gradients.

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- Q8. Which established CO2 Models are you using?

- A8. The reactions and parameters used for the CO2 model are described in the accompanying PDF documentation. The documentation contains references for any sources referenced in the development of the example model: https://www.comsol.com/model/carbon-dioxide-corrosion-in-steel-pipes-17255

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- Q9. Please advise if we can use COMSOL for sour corrosion prediction for wet gas pipelines. Mainly understanding impact of chloride this type of corrosion? Thanks.

- A9. Possibly, if the electrochemical reactions are known. The rates of conversion of species and stoichiometry of the reactions needs to be known. Sweet corrosion only modelling dealt with presently in our examples: CO2 corrosion https://www.comsol.com/model/carbon-dioxide-corrosion-in-steel-pipes-17255

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- Q10. Has real field data been used for enhancing Models?

- A10. The material data used in the version 5.6 material library is mainly taken from Technical Papers. If you have any particular materials you would like to define, then it is possible to make your own definitions.

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- Q11. What material range does this corrosion software address? and does it include non-metal materials?

- A11. The material library currently only contains corrosion data for metals and alloys.

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- Q12. What model formats of the asset can be used with Comsol, CAD, Solidworks etc. and which is the preferred type?

- A12. There is a large number of supported formats for import into COMSOL. These are listed on our website: https://www.comsol.com/products/specifications/cad/

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- Q13. Can COMSOL handle MIC / Bacterial Issues?

- A13. Yes, the corrosion processes / equations may be possible to model, however it would require All the chemical and electrochemical equations that are available in the literature to be defined / constructed in model.

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- Q14. What about the simulation of ICCP for steel in concrete structure?

- A14. As also discussed above in Q6.

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- Q15. Some papers don't give directly the value of current density, rather they provide an exponential relations between current density and electrode potential. Could we add equations in the current density that consider a variable potential?

- A15. Yes, this is possible. Polarization data can be imported using an interpolation function.

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- Q16. For other corrosive species [H2S/Ethanol/etc.], the dissociation and transport would have to be modelled and 'layered' over the sweet (CO2) corrosion model in order to see their influence? Basically, as long as the 'chemo-dynamics' (chemistry and reaction dynamics) are understood, Comsol can be used to model different electrochemical phenomena. It’s a tool, and its efficiency lies in the hands of the user.. Unless I'm wrong?

- A16. Yes. Generally, the key corrosion processes can be defined if the chemical and electrochemical reactions are understood and have the parameters available to define them.

THANK YOU FOR ATTENDING

This Webinar was brought to you by MCF working in partnership with ICorr Aberdeen and **COMSOL**.