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Institute of Corrosion (ABZ) partnering with:

EI and University of Leeds

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“Advanced once-through flow cell methodology for validation of a new ‘staged’ inhibition approach for matrix acidizing treatments”

Dr Joshua Owen PhD, University of Leeds

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…….Part of our Continuing Education Programme

About the Presenter

- Dr Joshua Owen PhD, J.J.Owen@leeds.ac.uk University of Leeds
- **Areas of expertise:**
- Corrosion; erosion-corrosion; electrochemical sensing; fluid mechanics.

- Dr Joshua Owen is a Research Fellow in the Institute of Functional Surfaces, School of Mechanical Engineering, with multidisciplinary research interests encompassing corrosion science, electrochemical sensing and nanotechnology. He has a breadth of expertise in the application of electrochemical and mathematical techniques to understand and model corrosion and erosion-corrosion phenomena, specializing, in the design of bespoke' flow systems to understand these processes. He has a diverse background of postdoctoral research, having previously developed a microfluidic, monolayer on-chip electrochemical biosensor for nanomaterial toxicity screening. His current research focuses on the augmentation of protective corrosion products in geothermal applications.

About the Topic

- Dr Joshua Owen PhD, J.J.Owen@leeds.ac.uk University of Leeds
- Research Fellow

“Advanced once-through flow cell methodology for validation of a new ‘staged’ inhibition approach for matrix acidizing treatments”

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- Schlumberger recently introduced and patented a new staged acid corrosion inhibitor (ACI) treatment concept for application in matrix acidizing treatments. The staged treatment concept recognises that treatments which employ a fixed dosage of corrosion inhibitor may not be optimal in terms of their efficiency. The concept proposes staged pumping of a first fluid composition designed to establish a persistent inhibitor film (Stage 1) and a second fluid composition to maintain the film and its associated inhibited corrosion rate (Stage 2). The staged ACI concept has the potential to provide enhanced corrosion protection of wellbore casing and coiled tubing (CT) materials whilst using the same total quantity of inhibitor compared to conventional treatments.

- Typically, the corrosion test methods used to evaluate this approach have involved preparing two equivalent pre-heated and conditioned glass reactors, one of which is used for the first film-forming stage and the other for the second film maintenance stage. This procedure is rather inconvenient and involves a short period of time (~1 min) during which the weight loss coupons or working electrode (a rotating cylinder electrode) are in contact with the atmosphere which could change the corrosion potential and could potentially have an influence on the inhibitor film formed during the first stage. In the present paper, a bespoke, electrochemical, millifluidic once-through flow cell was used for validation of the staged ACI concept by exposing a carbon steel coupon, mounted within the flow cell, to 4 M hydrochloric acid (HCl) flow at a temperature of 80 °C and a flow rate of 5 mL/min. A once-through flow cell enables testing in a continuously flowing environment whilst maintaining a fresh acid solution, a controllable supply of inhibitor, and eliminating any contact of the electrode with the atmosphere. The system was used to quantify changes in corrosion behaviour during continuous flow and during transitions from the first to second stage inhibitor dosages, to find optimal inhibitor concentration for film-forming and film maintenance stages and to investigate the effect of metal pre-corrosion on inhibitor performance for carbon steel used as wellbore casing and CT materials. In situ linear polarisation resistance measurements confirmed that an acetylenic alcohol-based polymerisable inhibitor, used at a concentration of 0.01 wt.% in Stage 2 after a 0.2 wt.% concentration film forming stage (Stage 1), maintained excellent corrosion protection of N80 (wellbore casing) and HS80 (CT) carbon steel, with corrosion rates of < 5 mm/year measured.

Q&A

Presentation – “Advanced once-through flow cell methodology for validation of a new ‘staged’ inhibition approach for matrix acidizing treatments”

Questions and Answers – ICorr ABZ / Energy Institute Joint Technical Event, **January** 2022

Q1. Have you tested the CI with HCR6000 acid system?

A1. No, we haven't tried this to date.

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Q2. How can you explain the increase in corrosion rate in slide 12, the increase in CI is known to enhance protection, i.e. film stability?

A2. Slide is for the Corrosion potential not the Corrosion rate.

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Q3. Are you planning to test the impact of proppant on the inhibitor efficiency?

A3. No proppant is used for fracturing not for acidising treatments.

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Q4. Is the polymerized inhibitor film conductive to enable LPR measurements? The flow speed in the test is very slow - how is an accelerated fluid flow to achieve a stable corrosion system?

A4. Film formed is very thin/conductive. More aggressive test parameters are being considered.

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Q5. In the corrosion rate analysis, did you consider or see pitting? What’s the acceptance criteria?

A5. Objective was to eliminate gen. corrosion. By Stand 0-1. CR range lbs/sq.ft and min pitting.

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Q6. In Slide 20 the corrosion rate is increasing after 4 hours. Have you tried to test it for more than that e.g.. 12 or 24 hours since actual stimulation can go more than 6 hours usually?

A6. In our tests 4 hrs only due to the injection period typically lasting from 4-6 hours. Evgeny' 6hrs +. Flow back period (after injection) has been previously studied using the flow cell at Leeds, in collaboration with Schlumberger (see Barker, R., et al. 2018. Corrosion Science, 138, pp.116-129)

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Q7. 1000mm/year corrosion rate was considered for experiment in some slides. Was it practically observed?

A7. Yes, have validated experiments. Up to 80 Deg. C

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Q8. Also, temperature more than 85 deg, can this ACI be applicable?

A8. Corrosion rate increases exponentially with temp.

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Q9. Thanks for your talk. I note that you use low field LPR for your flow cell corrosion rate determinations. The LPR approximation only holds if there are no other electrochemical oxidation or reduction processes occurring in the system. This assumption may not hold if you are using an inhibitor which is electro-polymerising a film forming inhibitor. Have you considered swapping LPR for electrochemical impedance spectroscopy with a view to decoupling the corrosion and polymerisation responses?

A9. LPR measurements do have limitations for corrosion inhibitor studies, however corrosion rates determined from LPR have been validated against mass loss experiments in these conditions. Care is taken to avoid excessive polarisation of the coupon in this environment, due to the potential for high corrosion currents and sensitivity of the inhibitor film to extreme polarisation (e.g. polarisation for Tafel analysis). EIS is very effective for understanding inhibitor performance, but requires 10-15 minutes of polarisation per measurement, potentially influencing the film. Will be investigated in future studies however.

Questions and Answers – ICorr ABZ / Energy Institute Joint Technical Event, **January** 2022

Q10. Is this a New recipe introduced by Schlumberger?

A10. The chemical used for study is an acetylenic alcohol type inhibitor blended for acidizing operations.

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Q11. Last question from me is the impact of chloride, are you planning to test its impact, since chloride can impact persistency of inhibitor film. Thanks

A11. We are already using High Conc. HCl so there is no need for it really.

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Field Trials are our planned next step. There have been Covid delays….refer SPE earlier paper. **SPE-205032.**

Should you have any further questions related to this Webinar,

Please contact: Dr Joshua Owen PhD, J.J.Owen@leeds.ac.uk
University of Leeds who will be very pleased to assist you. Thank you.

THANK YOU FOR ATTENDING

This Webinar was brought to you by ICorr Aberdeen working in partnership with the **Energy Institute and University of Leeds.**