JUBCOR 2022
CONFERENCE & EXHIBITION

FRETTING CORROSION IN STEAM REBOILER TUBES

PRESENTED BY:

Muhammad Raheel Rafique
(Lead Engineer Static Equipment)
PETROKEMYA – A SABIC Affiliate

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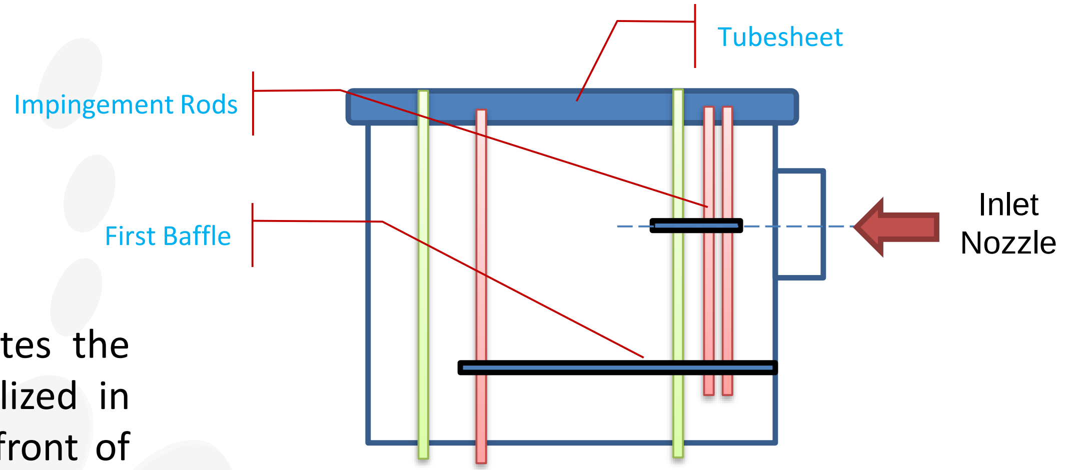
PREFACE

- Condensation at the baffle surface of LP Steam Reboiler (Shell & Tube Type) is expected when the operating temperature is the steam's saturation temperature at the operating pressure. However, considering the relatively short life of the tubes, something might have occurred that is not expected in steam applications, resulting in a faster degradation rate.

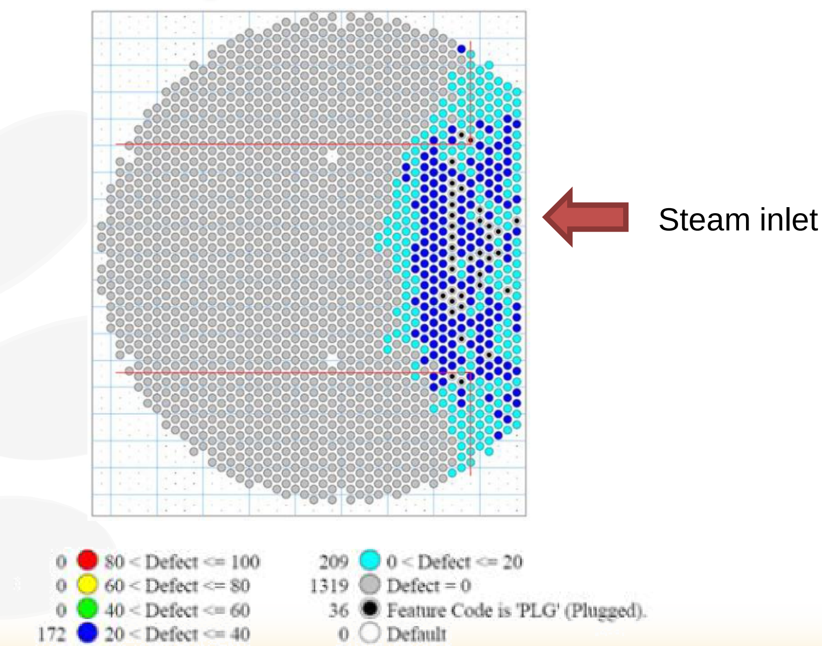
- The case study to be presented is the assessment of a Shell & Tube type LP Steam Reboiler, with the history of repeated failure in the tubes at certain locations due to Fretting Corrosion, caused by the combined effect of high inlet velocities and condensation of the steam.

TUBE SCANNING RESULTS



- History of tube scanning indicates the high rate of thickness loss localized in the tubes which are located in front of the inlet nozzle.

- Magnetic Flux Leakage (MFL) inspection performed throughout the length of the tubes, identified the flaws located nearby the first baffle of the exchanger.



STEAM WETNESS

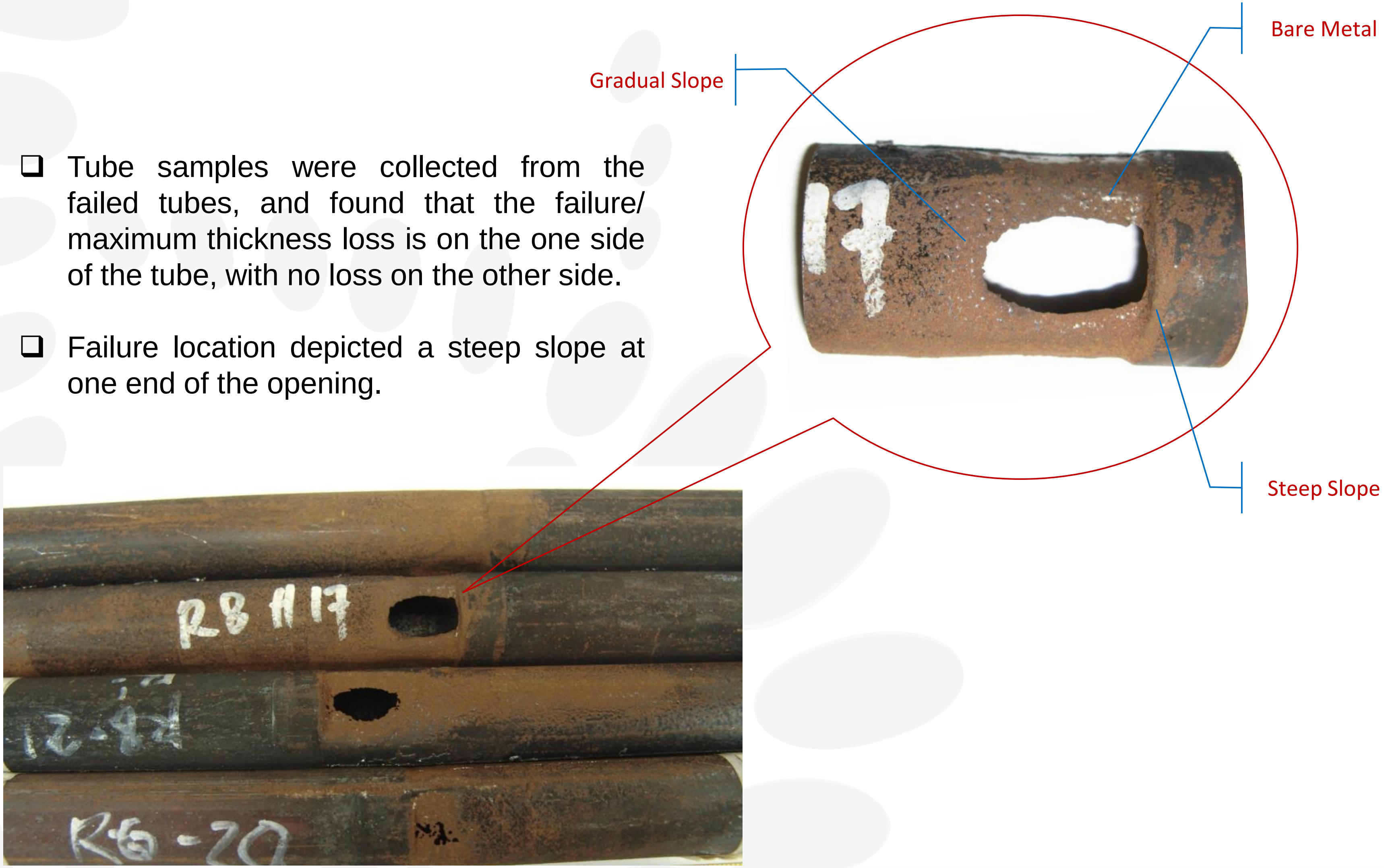
- Suspecting the steam quality, the steam data was analyzed to check the possibility of steam condensation at the inlet nozzle.
- No steam wetness found at the operating conditions.

SATURATED STEAM - TEMPERATURE TABLE

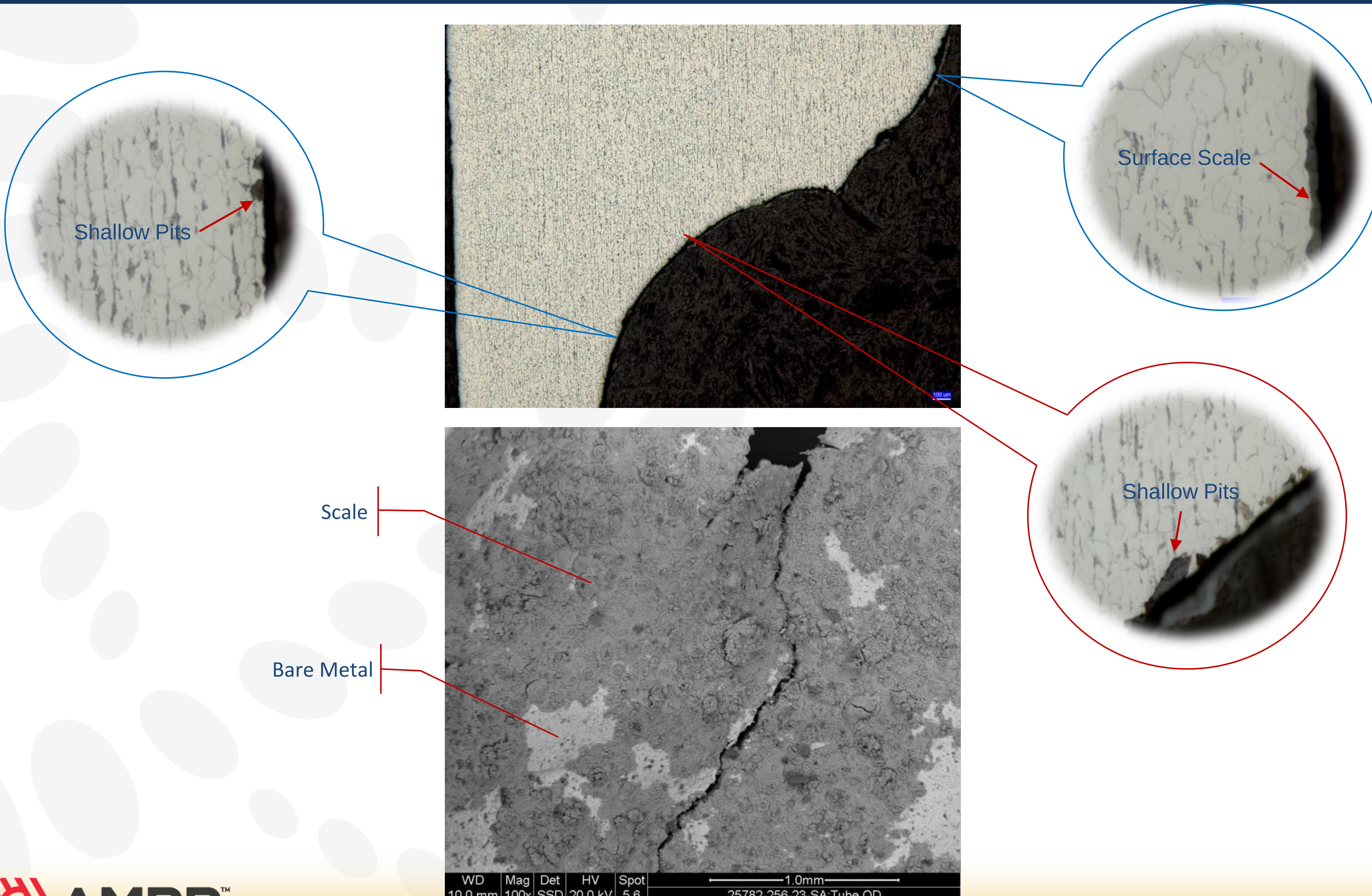
		Spec. vol. m^3=kg		Int. Ener. kJ/kg		Enthalpy kJ/kg		Entropy kJ=(kg°K)	
T °C	P bar	Sat. liq. v_f X1000	Sat. vap. v_g	Sat. liq. u_f	Sat. vap. u_g	Sat. liq. h_f	Sat. vap. h_g	Sat. liq. s_f	Sat. vap. s_g
85	0.5783	1.033	2.828	355.8	2488	355.9	2652	1.134	7.544
90	0.7013	1.036	2.361	376.8	2494	376.9	2660	1.193	7.479
95	0.8455	1.039	1.982	397.9	2501	398.0	2668	1.250	7.416
100	1.013	1.044	1.673	418.9	2507	419.0	2676	1.307	7.355
110	1.433	1.052	1.21	461.1	2518	461.3	2691	1.418	7.239
120	1.985	1.060	0.892	503.5	2529	503.7	2706	1.528	7.130
130	2.701	1.069	0.669	546.0	2540	546.3	2720	1.634	7.027
140	3.613	1.080	0.509	588.7	2550	589.1	2734	1.739	6.930

TUBE SAMPLES

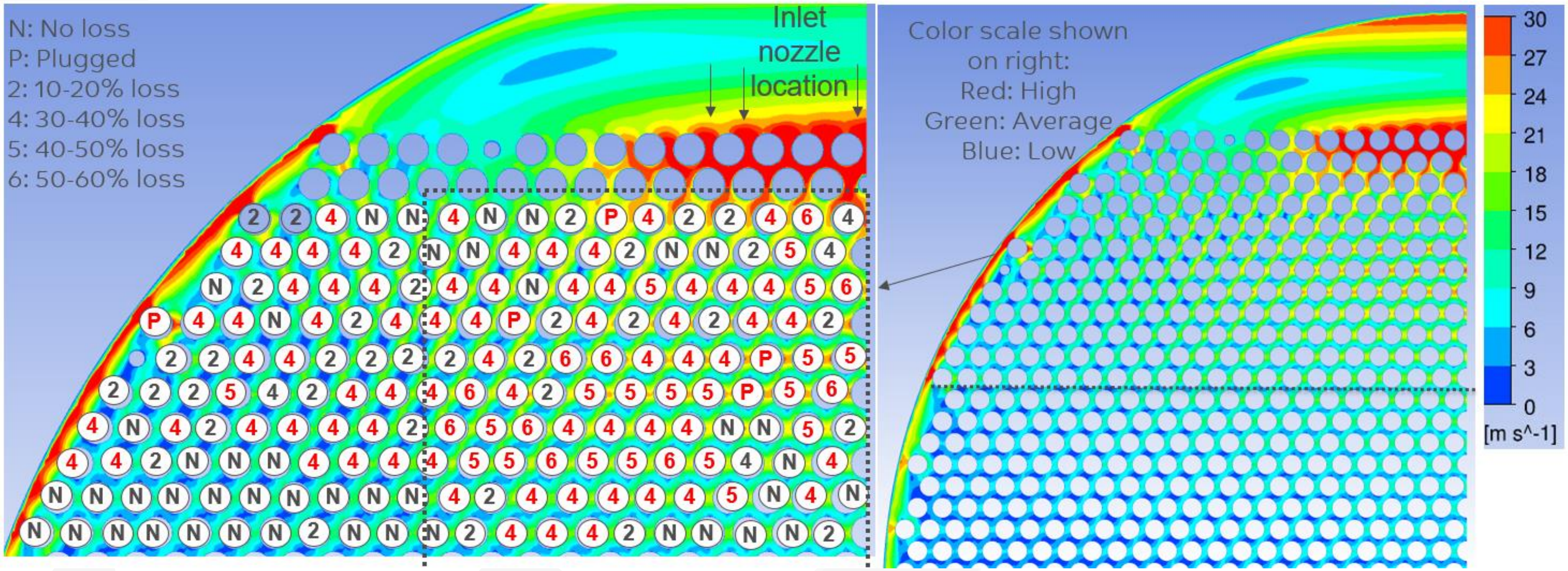
- Tube samples were collected from the failed tubes, and found that the failure/ maximum thickness loss is on the one side of the tube, with no loss on the other side.
- Failure location depicted a steep slope at one end of the opening.



ANALYTICAL ANALYSIS



CFD – VELOCITY TRENDS

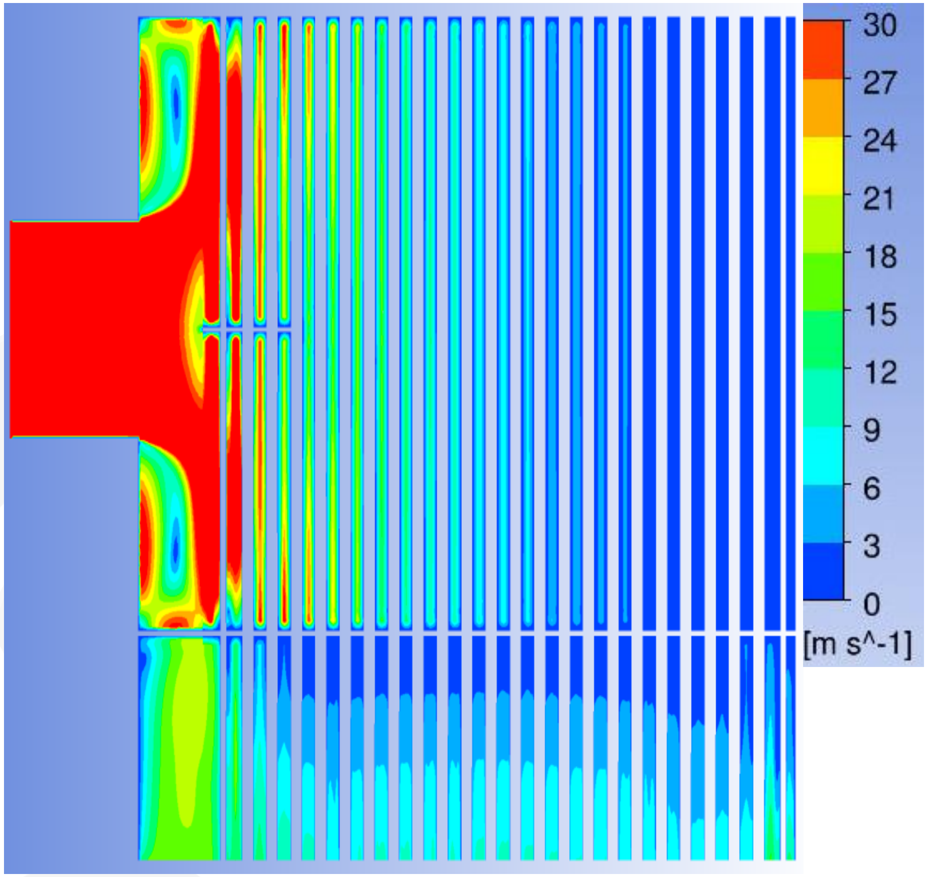


Computational Fluid Dynamics (CFD) Analysis performed to check the flow morphology and determine the flow velocity at the inlet nozzle. Below are the results:

- ❑ CFD results are superimposed with tube thickness reduction from inspection report.
- ❑ Most tube damage is on tube rows close to the inlet and once directly below inlet nozzle.
- ❑ No wall thickness loss is observed, once the velocity is reduced beyond 15-20 tube rows.

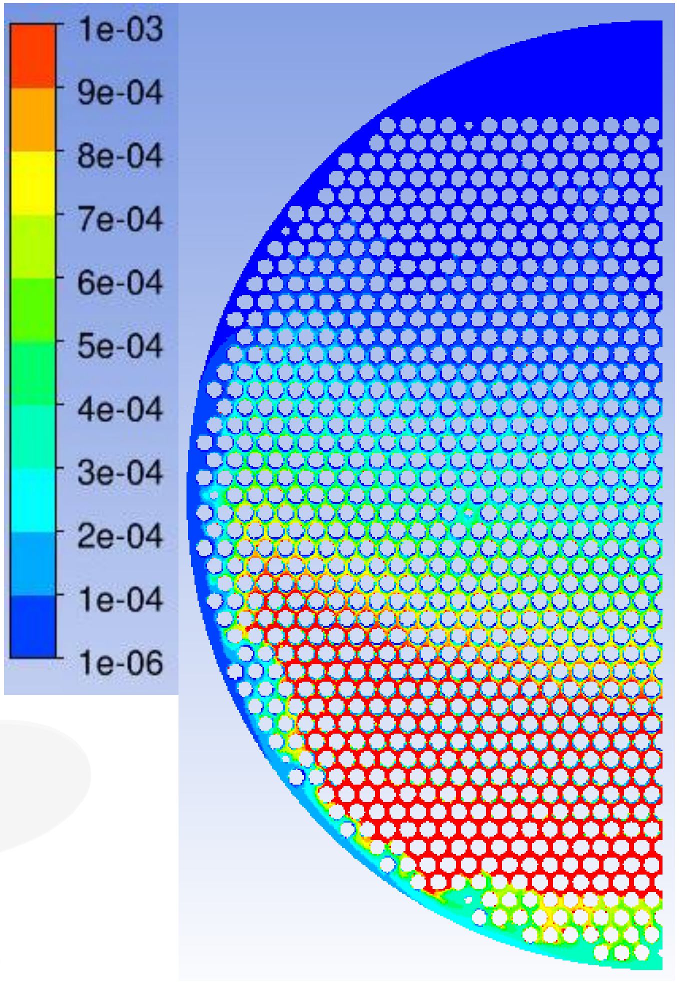
CFD - VELOCITY TRENDS (SYMMETRY PLANE)

- ❑ High velocities observed close to the inlet nozzle.
- ❑ Velocity distribution becomes uniform approx. 10 – 15 tubes below.



CFD – CONDENSATION PLOT

- Volume Fraction of condensed water as per CFD Analysis.
- Most damage seems to be concentrated in regions of no or low condensation close to the inlet.



CONCLUSION

- From the results of Analytical as well as CFD analysis, it can be concluded that the *'Fretting Corrosion'* is the most probable damage mechanism causing tube failures due to high rate of thickness loss.

- Fretting is an erosion process enhanced by corrosion. Fretting occurs when one surface vibrates against another one in a dry or humid environment. Moisture enhances fretting because it creates a corrosive environment but too much water tends to lubricate the contacting surfaces and stifles fretting.

- Tube anti-vibration measures can mitigate this issue of frequent tube failures. Some of the measures are: changing the natural frequency of the heat-exchanger by reducing the tube span; reducing the clearance between the tube and hole in the baffle plate; increasing baffle thickness; changing impingement rods design; reducing flow velocities etc.

ACKNOWLEDGMENTS

The author gratefully acknowledge the support provided by SABIC R&T group for the CFD simulation and SABIC ATC for Analytical Analysis:

- ❑ Sharma, Ananth *(Staff Scientist, Feedstock & Cracker MEA) – SABIC R&T*
- ❑ Funani, Sivuyile *(Sr. Engineer, Materials, Materials Engineering) – SABIC ATC-AI*

Thank You

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