Electromagnetics: A Sustainable Approach to Solve Inorganic Scale Problem in the Energy Industry

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What is the problem?

Inorganic scale deposition is a common issue that disrupts the flow of the oil/liquid within the energy industry. Common example of a scale is limescales formed on the kettle in households.

How the problem is solved typically?

The energy industry uses chemicals to eradicate the inorganic scales from wells which are costly, result in longer well down time and can have a negative impact on the environment.

Why new approach?

As the energy industry is transitioning to reduce its carbon footprint, there is a need for an alternative approach which is sustainable, low cost and safe.

What's new in the approach?

A radio frequency signal is used to impart an electromagnetic (EM) field onto the pipe surface and production fluids, changing the scale formation process. Implementation of such a system in the energy industry can be challenging and therefore, we use an Ansys 3D electromagnetic simulation software which uses a finite element method to solve such a complex structure.

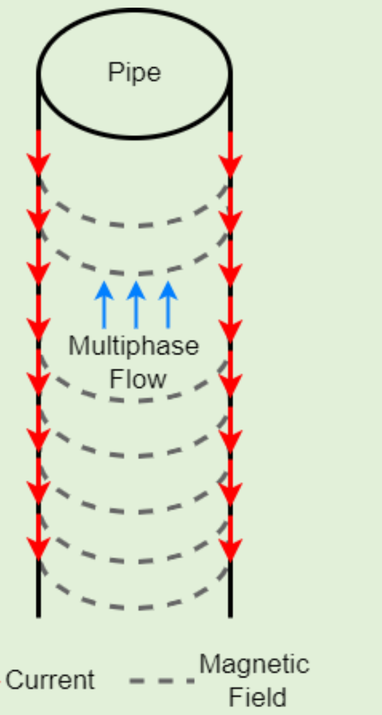

Fig 1: An illustration of the pipe model with multiphase flow (oil, water and gas) along with the direction of induced currents and magnetic fields.

Operating Principle

The technology is based on the impact of the electromagnetic field on the ions present in the fluid. The interaction between the EM field and ions, changes the electron spin of the ions to an excited state and as a results a new structure is formed.

This phenomenon tiggers the homogenous nucleation and leads to the formation of solids in the bulk rather than on the metallic walls [1].

This process is applicable for ions which have diamagnetic properties.

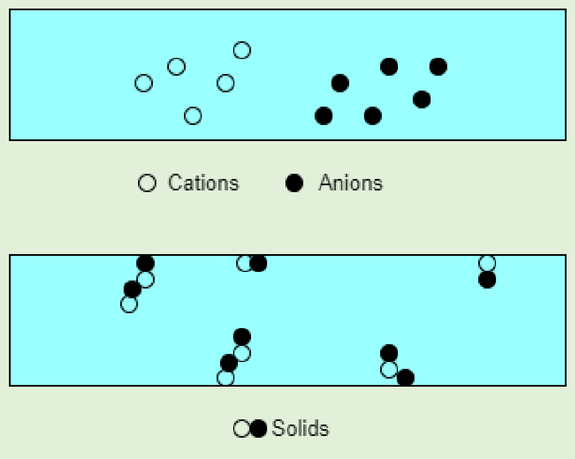

Fig 2: Cations and anion forming a solid structure and adhering to the metallic surface (no magnetic field present).

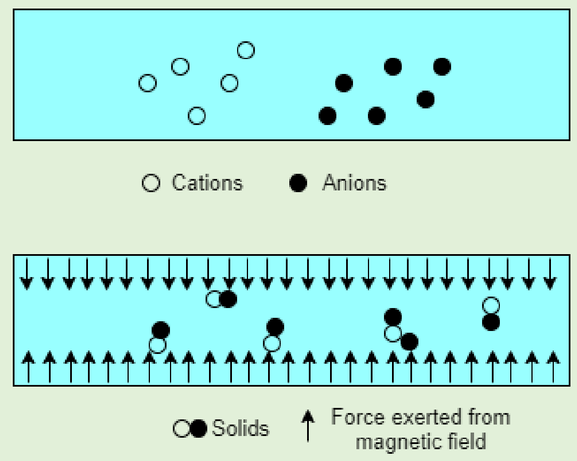

Fig 3: Cations and anion forming at the bulk and are not adhering to the metallic surface due to the presence of the magnetic field.

Methodology

Objective: *To understand the working mechanism of the system in an EM field environment.*

Electromagnetic Field Simulation

Setup: A 2m pipe was designed in the electromagnetic simulation software. Since the inorganic scale can form anywhere in a pipe, the whole pipe was excited with the EM field.

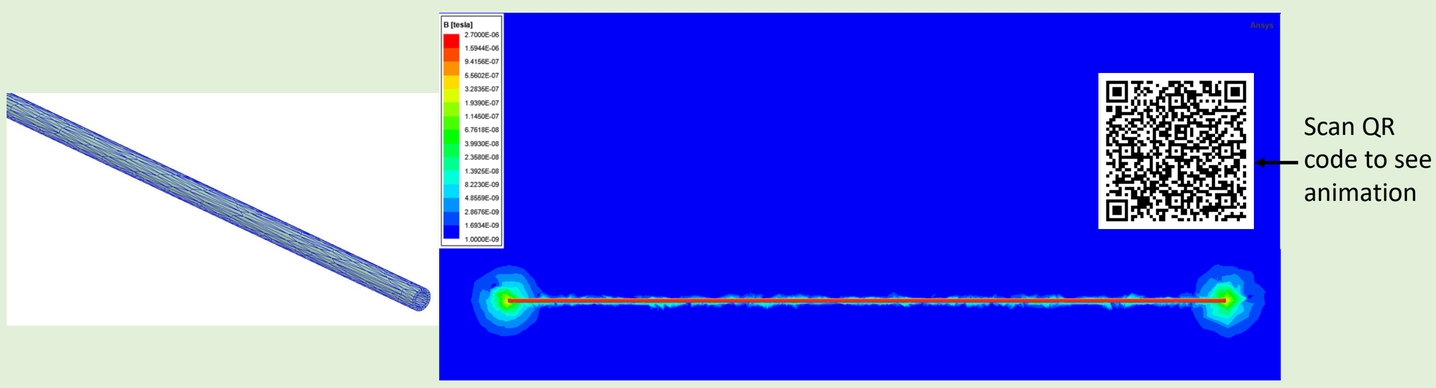

Fig 4: Left: a "meshed" design of a 2 metre pipe. Right: Animations showing magnitude of the magnetic field within the pipe.

Result: The simulation shows presence of the magnetic field in the entire pipe.

Laboratory Testing

Setup: The 2 metre pipe was used to run an experiment both with and without EM fields.

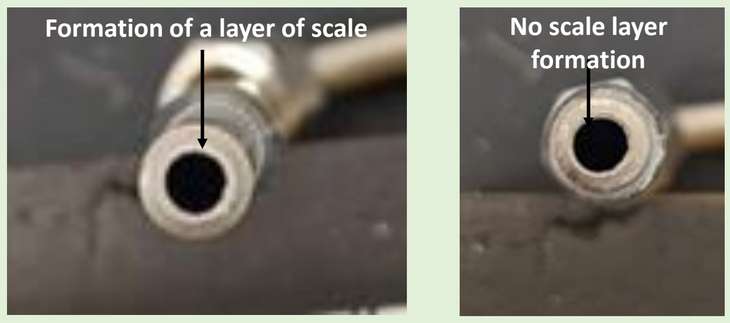

Fig 5: Left: Without magnetic field and Right: With magnetic field

Result: It was observed that in the presence of the magnetic field, the inorganic scales were not adhering to the metallic wall of the tubing.

Conclusion

- ✓ *The work introduces an alternative approach to solving inorganic scale deposition.*
- ✓ *The electromagnetic simulation model validates the presence of a magnetic field in a pipe.*
- ✓ *The laboratory experiments provides clear evidence that there is a significant effect of magnetic field which reduces inorganic scale formation.*
- ✓ *The proposed innovative technology provides a long-term scale prevention solution which is cost effective, low risk and sustainable.*

References

[1] Singleton, Michael A., and Ivan R. Davis. "Experimental Investigation of the Impact of Electromagnetic Devices on Barium Sulphate Scaling." Paper presented at the SPE International Oilfield Scale Conference and Exhibition, Virtual, June 2020. doi: https://doi.org/10.2118/200664-MS

[2] Balanis CA. Advanced engineering electromagnetics. John Wiley & Sons; 2012 Jan 24.