COMBATTING CORROSION IN HEATING AND COOLING SYSTEMS

Corrosion is one of the most significant threats faced by buildings and infrastructures, with an annual global cost estimated at $2.5 trillion. Occurring when a metal reacts with chemicals, such as dissolved oxygen, corrosion transforms the metal into a build-up of minerals. Corrosion is inevitable in virtually every engineered system that uses water for heat transfer.

In recent years, owners of many modern buildings are finding that corrosion is becoming more problematic than before. In the past, these issues were virtually non-existent for buildings less than two years old, but now, corrosion is becoming commonplace in modern heating and cooling installations.

These modern systems require far less energy and water than their older counterparts. However, they also provide ideal environments for corrosion. In a study published in Energy Procedia, Dr Oliver Opel at the West Coast University of Applied Sciences aimed to get to the bottom of this mystery.

In this study, Dr Opel and his team investigated 64 heating and cooling systems, installed across 21 different buildings. After cleaning each system, and leaving them to operate for 24 hours, they used sensors to measure several properties of the water they contained, including pH, temperature, oxygen levels and microbial diversity. They then compared these readings with measurements from older systems.

This allowed the researchers to identify several reasons underlying the growing corrosion problem, the first of which was water temperature.

Water in older heating and cooling systems needs to be kept at temperatures higher than 60°C, in order to keep it flowing quickly through the pipes. At these high temperatures, the pipes' steel surfaces react with oxygen to form a mineral named magnetite. Forming thin layers inside the pipes, magnetite protects the steel underneath from further corrosion. Dr Opel's team realised that improvements in engineering mean that the water within modern systems can be kept at lower temperatures. However, these conditions mean that magnetite no longer forms, leaving the pipe surfaces unprotected.

The second reason identified by the team involves metal-corroding microbes. Previously, the hot, oxygen-depleted environments characteristic of older heating and cooling systems were difficult places for microbes to survive, which meant that only a few types could grow. In modern systems, the cooler, oxygen-rich water is ideal for a wide variety of microbes to thrive. The researchers identified around 600 different species, which fell into distinct groups – each of which promoted corrosion in a unique way.

Having identified these corrosion mechanisms, the team wished to provide engineers with updated solutions for tackling the problem. There was one prevention technique that they found to be effective in combating corrosion: the use of demineralised water. Dr Opel suggests that all impurities should be removed using reverse osmosis, where water is passed through a fine membrane. Without these impurities, microbes cannot locate essential nutrients, keeping systems sterilised. Reverse osmosis also removes many chemicals that directly corrode metal.

Confirming their predictions, the team's experiments revealed that systems using demineralised water remained the most resilient against corrosion. They suggest that if a system using demineralised water were continuously monitored using sensors, the problem of corrosion could finally be curtailed. Their insights could prove critical to ensuring that heating and cooling systems can continue to increase in efficiency, while maintaining functionality over time.

Original article ‘Corrosion in Heating and Cooling Water Circuits - A Field Study’ published in Energy Procedia at: https://doi.org/10.1016/j.egypro.2018.11.042

Dr Oliver Opel Professor for Energy-optimised Buildings West-Coast University of Applied Sciences Heide Germany

Contact E: opel@fh-westkueste.de W: https://www.fh-westkueste.de/hochschulprofil/ansprechpartner/professoreninnen-technik/prof-droliver-opel/

Acknowledgement/// We thank the German federal ministry of economics and energy as well as our team in Lueneburg, Braunschweig and Heide, especially Tobias Otte and Dr. Tanja Eggerichs for their valuable work in the field!