Use of district cooling or air conditioning is growing dramatically in Sweden and Europe. In office premises and larger buildings such as hospitals and shopping malls, air conditioning is the rule rather than the exception. In recent years we have seen a marked increase in damage due to corrosion in air conditioning systems. This is despite the fact that their expected service life is around 30–40 years.

Corrosion in air conditioning systems

– a growing problem

LISEN JOHANSSON, research engineer at Swerea KIMAB explains that the number of instances of damage is likely to continue to increase, since the use of indoor climate control systems is on the rise, this is probably only the tip of the iceberg. In many cases the damage is due to internal pitting; i.e., the thin copper tubing in the chilled beams of the system becomes perforated, often after only a couple of years of use. Swerea KIMAB recently arranged a seminar for a diverse group of interested parties to shed some light on the problem.

Causes of damage

Often, the instances of corrosion damage that Swerea KIMAB encounters, have several causes. One common scenario is when oxygen leaks into the system, causing cast iron or steel pumps in sub-systems to corrode. The presence of oxygen is a precondition for corrosion to occur. Ferrous/ferric corrosion products are carried in the piping, leading to problems in the form of either under deposit corrosion or bimetallic corrosion. Ferrous/ferric corrosion products are more noble than copper; therefore, a galvanic cell forms, with copper as the anode. Consequently, local corrosive attacks occur in the copper tubing, instead of more evenly distributed general corrosion.

One question that remains unanswered is why air conditioning systems are subject to pitting, but not tap water systems, despite the fact that oxygen concentration is many times greater in tap water systems. This may be explained in part, by the fact that tubing in air conditioning systems is considerably thinner, normally only 0.3-0.4 mm, as opposed to tap water piping, which usually has a thickness of about 1 mm. Thin tubing means that corrosive attacks can quickly result in leakage. Variations in the water chemistry of the different systems may also be another explanation. Carbonates in tap water contribute to the formation of a protective coating on the copper surface, thereby preventing further corrosion attacks.

Inspection and maintenance procedures

Most property owners lack procedures for inspection and maintenance of these systems. The first indication that something is wrong is that a leak occurs, in which case corrosion is already well advanced and the entire system may have to be replaced at great expense.

The fact that the system can suffer a corrosion failure after only a short period of time implies a considerable cost for the property owner or the party responsible for assuming the cost, for example, the insurance company or HVAC firm. When a system must be repaired or replaced, material costs constitute only a part of the total cost. For example, a chilled beam costs approximately 15,000–20,000 SEK and a large building may have anywhere from several hundred to thousands of units. Add to that the cost of labour for replacing the system, as well as the lost income incurred due to downtime for repairs and the sum quickly becomes very large. When chilled beams and piping are installed above ceilings, renovation work involving extensive dismantling entails dissatisfied tenants and loss of rental income. Many instances of leakage have also resulted in damage claims in cases where leaking cooling water has caused major problems with electrical components, computers, servers and instruments, etc.

Cross-section of damaged chilled beam. In the background, corroded copper tubing.

Environmental aspects

A corroded system will not transfer heat optimally, since the porous corrosion products deposited inside the tubing reduce the efficiency of the system, leading to increased energy costs. In addition, there are many suspended substances in the cooling water which, in some cases, may be environmentally hazardous if they are discharged. In several of the air conditioning systems that have been inspected, high contents of dissolved copper have been discovered. In a normal system, which contains approximately 5–10m3 of cooling water, this equates to a large amount of copper.

In cases where there are no procedures for bleeding the system or where leakage occurs, there is a risk that much of the dissolved copper may end up in sewage treatment sludge. High concentrations of other environmentally hazardous substances, such as lead, may also be detected in the cooling water.

Beautiful but undesirable. Electron-microscope image of copper corrosion products.

Solutions

If the problem is discovered early preventive measures can be taken. The first action to be taken is to find the root cause and prevent oxygen from entering the hermetic cooling system. Cooling water chemistry can be adjusted or inhibitors can be added. However, the problem with inhibitors is that if they are used incorrectly they can cause more harm than good; therefore, the technician must have good knowledge of both the inhibitor and the system to be able to achieve the desired result.

The article appeared previously in VVS Forum 2013.

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District cooling systems, often referred to as air conditioning or HVAC systems are hermetic systems consisting of copper tubing coupled to chilled beams in which heat transfer from the ambient atmosphere takes place via aluminium plates. As required, chilled water is circulated through the system and the building is cooled to a comfortable temperature. Systems are normally shut down during periods of cool weather.

Hello there...

Rachel Pettersson – Associate Professor at KTH

RACHEL PETTERSSON has been appointed Associate Professor of Corrosion Science at the Royal Institute of Technology's (KTH) School of Chemical Science and Engineering. Rachel, who is Research Manager at Jernkontoret (Swedish Steel Producers' Association), will devote 20 percent of her time to the position. The subject area of the associate professorship concerns the relationship between microstructure and corrosion properties of steel and metals. The position has been funded by the Hugo Carlsson Foundation and with support from Swerea KIMAB.

Specialist knowledge in the field strengthens KTH

To intensify corrosion studies in combination with advanced techniques for microstructural characterization, capacity for research within the field at KTH will be augmented. Rachel is ideally suited to the task, owing to her broad specialist knowledge of both corrosion and metallurgical physics, and her professional experience in leading research positions in industry and academia. She was appointed Docent in Corrosion Science at KTH in 2004 and has a very strong scientific background. One of Rachel's main tasks will be to supervise doctoral students.

– I am especially pleased to be able to offer more support to industry doctorates, who face a tough challenge in combining doctoral studies with their work in industry or at research institutes, says Rachel.

World-leading expertise has grown through long-term collaboration

Based on close cooperation between universities, institutes and industry, Sweden has acquired world-leading expertise in the area of corrosion in metallic materials. This strong position has been achieved largely due to long-standing collaboration with companies whose corrosion-resistant products have won strategic competitive advantage on the world market. Examples of companies that fit this bill include Sandvik, Outokumpu, SSAB and SAPA.

– One of my goals is to promote increased collaboration among corrosion researchers at KTH, Swerea KIMAB and within the Swedish metals industry, explains Rachel Pettersson.

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Inspection and NDT of polymeric and composite materials

The first of three workshops on reaching consensus in industry concerning inspection, damage assessment and non-destructive testing (NDT) of fibre-reinforced plastic (FRP) was held in Kista early this year. Participants included about 15 specially invited materials manufacturers, product users, inspectors and researchers.

The workshop is part of a larger project of which the aim is to produce a "damage atlas" and a handbook which, together, will serve as a common tool that can be used by inspectors, owners and users of plastics and FRP products, and others to assess defects. Opportunity was given during the workshop to raise relevant issues with respect to compilation of the atlas and to reach consensus concerning damage assessment of polymeric materials. The next workshop will be held in the autumn. Focus will be placed on a selection of the available NDT techniques for inspecting plastic materials: x-ray, ultrasound, infrared thermography and visual inspection.

The project is funded by Värmeforsk (Thermal Engineering Research Institute) and the Swedish Energy Agency, and is arranged in collaboration with Swerea KIMAB, Inspecta, Termap and Bodens Energi.

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