PREPARATORY INDUSTRIAL PROJECT

Understanding degradation mechanisms in PUR foam for district heating pipes using Computed Tomography

THE INDUSTRIAL CHALLENGE

Polyurethane (PUR) foam is used as an insulation layer in district heating pipes. During operation, the combined loading causes the foam to degrade (Figure 1). Consequently, pipe performance, i.e., insulation capacity, is reduced and the environmental benefits of district heating are compromised.

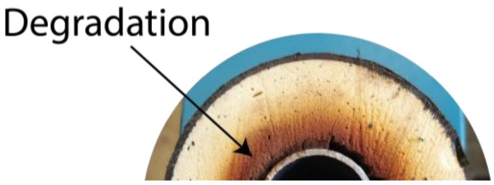

Figure 1. District heating pipe illustrating the degradation of the insulating PUR foam.

WHY USING A LARGE SCALE FACILITY?

The project aimed to design an experimental approach to study the degradation of the PUR foam and understand how the cell structure changes due to the degradation using synchrotron x-ray tomography. In operation, PUR degradation is driven by a combination of thermal and mechanical loading. To mimic this process in an accelerated fashion is non-trivial, as elevated temperatures can trigger degradation mechanisms that are not relevant. From lab-based x-ray tomography studies of aged and non-aged samples the scales of interest and associated resolutions for the imaging could be identified to, thus, define the focus of future synchrotron x-ray tomography experiments. In particular, it was found that sub-micron spatial resolution over a cm size volume is required to address the key challenges of quantifying how the number of closed cells changes with increasing degradation and how the cell walls thin. This is in line with the capacity of eg the TOMCAT beamline at the Swiss Light Source of the Paul Scherrer Institute. The SYRMEP beamline at Elettra was also identified as a good facility to achieve the high resolution and large field of view imaging and a new application to this facility is being discussed.

THE RESULTS AND EXPECTED IMPACT

The project brought together industry, institute, and academia to understand the challenges relating to PUR foam degradation and the possibilities of x-ray tomography imaging. The advanced x-ray measurement methods were entirely new to the industrial partners, but their knowledge of the material and processes guided the project towards identification of the key questions. Imaging of non-aged and aged samples of PUR foam at different resolutions enabled the imaging challenge, relative to the material one, to be understood. Consequently, it was possible to develop a proposal for a synchrotron imaging experiment. The expected outcomes from this project, and subsequent synchrotron imaging, are new understanding of the thermo-mechanical degradation of PUR foam to be coupled with numerical modelling for optimised material development and utilisation.

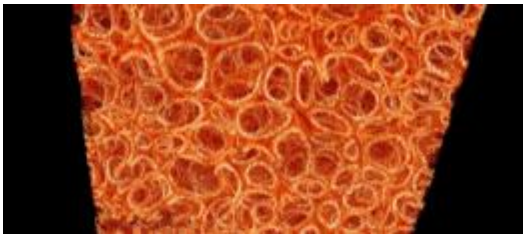

Figure 2. Visualisation of PUR cell structure.

***"With deeper future knowledge about the material, for example regarding degradation, you have better opportunities to take development steps forward"* / Jan Frick, Powerpipe**

Contacts: Jan Frick, jan.frick@powerpipe.se | Dragan Vasic, dragan.vasic@sonoform.se
Erik Dartfeldt, RISE, erik.dartfeldt@ri.se | Stephen Hall, stephen.hall@solid.lth.se

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