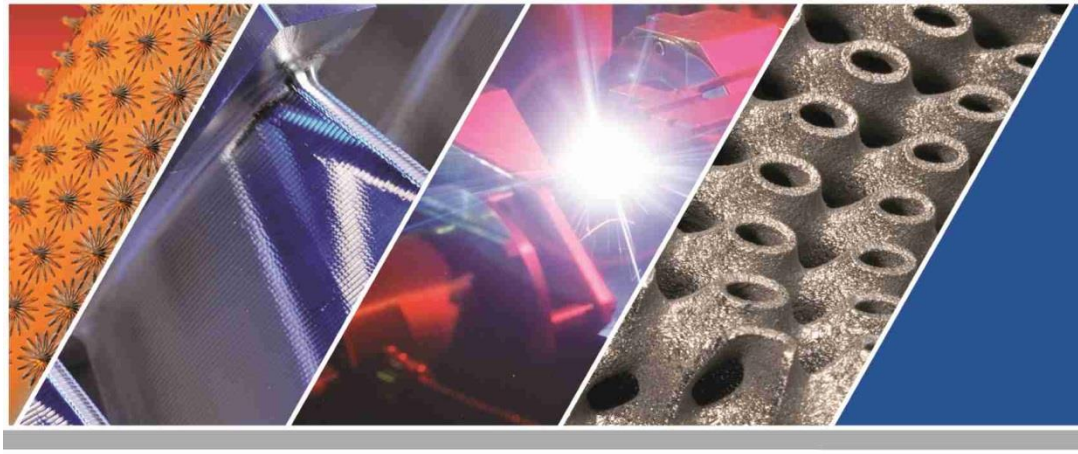
Combined Permeation of Pressurised CO_2 and Impurities through Thermosets



JOINT INDUSTRY PROJECT OUTLINE

PROP310931

Summary

Overview

In applications for carbon capture and storage or enhanced oil recovery that include steel pipe remediation or lining, there is a need to assess the barrier performance of polymeric materials that are primarily thermosets. Specifically to establish their potential use as barrier layers to impurities in carbon dioxide (CO_2) feedstock such as water vapour, ammonia, nitrous oxide, hydrogen and hydrogen sulfide. Generally the liner reduces the rate of arrival of corrosive species at the load bearing steel support wires or base pipe.

The CO_2 fluid compositions may vary between locations and, potentially, there will be an enormous cost to the industry and an environmental impact of needing to expose thermoset systems to each fluid composition in a case by case approach to autoclave based ageing studies.

This study aims to establish whether some impurities are selectively blocked by the internal structure of the thermoset resin and so these can be excluded from screening studies for ageing in the future.

The chosen thermosets will be from the epoxide group, cross linked with aliphatic or aromatic amines, depending on the required glass transition temperature and mechanical properties. There will also be an interest in exploring options for epoxy formulations that contain flexibilizers in the form of additives or extended chain chemistries. TWI Ltd will work with the JIP sponsors and third party suppliers to acquire the material as appropriate for the JIP.

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Permeation of pressurised CO_2 with impurities through thermosets

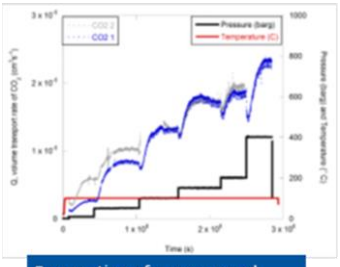
Project Concept

Establish selectivity for impurities in the presence of pressurised CO_2

The project will use the established TWI permeation facility, supported by gas chromatographs, to measure over several months the rate of transport through thermosets of CO_2 with water vapour and trace amounts of one of hydrogen sulphide, ammonia, nitrous oxide or hydrogen. It is expected that the concentrations of the impurities will be of the order of 500ppm. In any one permeation test, the pressures and temperatures of the CO_2 feed can start in the gaseous phase and be pressurised to liquid at 500barg with the temperature altered above 31°C to create a supercritical fluid.

Where transport is detected, then the flux and permeability coefficients will be calculated for each species at each pressure and temperature step. This may allow the activation energy for permeation to be determined. Assuming that initial breakthrough is captured, then diffusion coefficients will be calculated at various temperatures with the potential to estimate the solubility and enthalpy of adsorption of each component.

Using this data, it is hoped that the expected transport levels at other pressure and temperature conditions can be estimated. The analysis of the thermoset will be for swelling, alteration in crystallinity, glass transition temperature, storage and loss modulus.



Permeation of gaseous and liquid CO_2 containing H_2S

Thermoset damaged with release of high pressure CO_2

Objectives

- To establish the barrier performance of thermoset materials to CO_2 with associated impurities.
- To establish if any transport of these impurity species causes ageing in the thermoset matrix.

Benefits

This work will provide guidance as to which generic CO_2 composition with impurities are relevant to assess the barrier properties and ageing of thermosets.

Approach

Permeation and assessment studies on small disc specimens

The permeation of liquid and supercritical CO_2 through extruded thermoplastics from supercritical mixtures has been studied extensively over the last decade because of their use in liners for traditional flexible risers and flow lines.

As a result, TWI has a facility to carry out continuous sweep permeation testing using supercritical CO_2 pressurised to 626barg in the presence of H_2S.

Building on established methodologies with the addition of an impurity with water to the CO_2, this work will be extended to thermosets. The choice of the impurity will depend on the chemistry of the thermosets and the wishes of the sponsors. It will be important to include water.

Four multistep permeation tests can be performed with an overall duration of 3 months each. The condition of the thermosets after exposure will be assessed. The experimental methodologies used and data treatment will act as a guide irrespective of the functionality of the thermoset in the final product, be it a thermoplastic composite pipe or a polymer lined steel pipe or tubular.

Permeation studies on reinforced thermoset pipe sections

In the facility at TWI Ltd, there is also the option of carrying out a radial and axial permeation or an exposure test on a pipe product with a length of 3 metres and a nominal diameter of 100mm. The pipe product may be multilayer to include a steel host pipe and include connectors. Such an experiment might include a metallic host part with a fibre reinforced thermoset liner. The permeation test would be run for a period of one year with post exposure dissection and analysis being completed in year 3, as an example.

Deliverables

This JIP will provide permeation data to confirm if the contaminants enter into the thermoset materials and so have the potential to contribute to ageing of the thermoset matrix.

Price and Duration

The overall estimated price for the work is £300,000 (excluding VAT), which requires £25,000 per company per annum for 3 years (£75,000 total) from each of the 4 Sponsors. It is anticipated that the project will commence with an agreed scope of work with a minimum of 4 Sponsors. If the number of sponsors increase then the ticket price can reduce or scope of work increase accordingly.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

https://www.twi-global.com/what-we-do/research-and-technology/current-research-programmes/joint-industry-projects#/

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