Department for Science, Innovation & Technology

Thermophysical Insights for Hydrogen–Natural Gas Blends in Transmission Networks

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Add value.
Inspire trust.

Introduction

- The integration of H_2 into the natural gas (NG) system

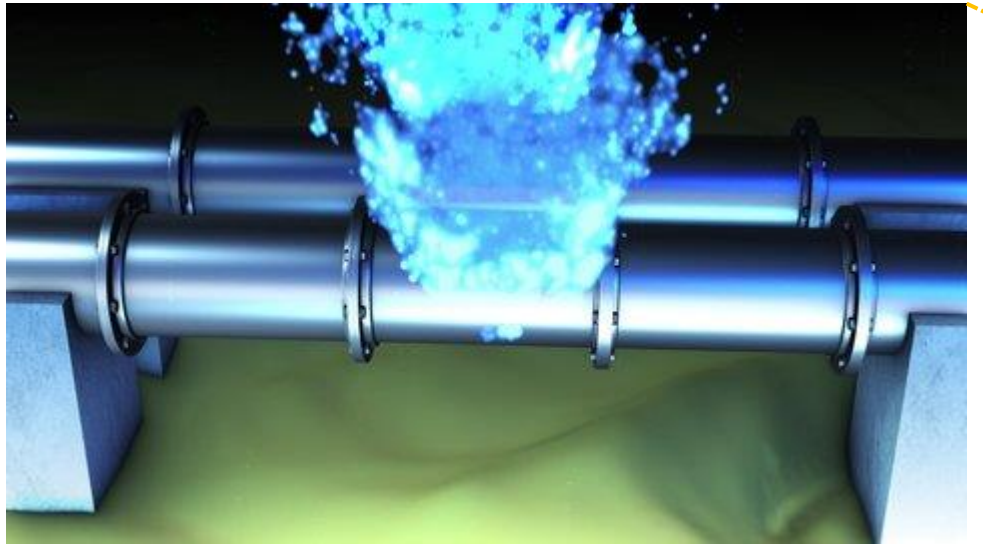
- **H_2/NG streams in transportation pipelines** will contain several components.

- Using **equation of state (EoS)** to determine thermophysical properties for H_2/NG process design and operation. (**flow assurance and flow metering** aspects)

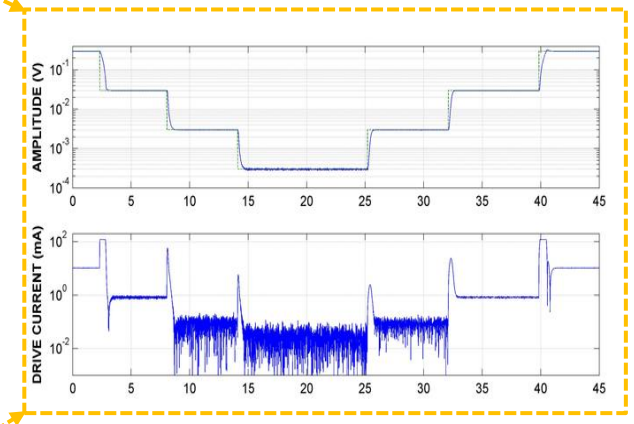
- We used a **brand-new experimental dataset** and investigated modelled thermophysical properties relative deviations using four EoSs.

What are the key concerns around H_2/NG transport infrastructure

Leak detection!



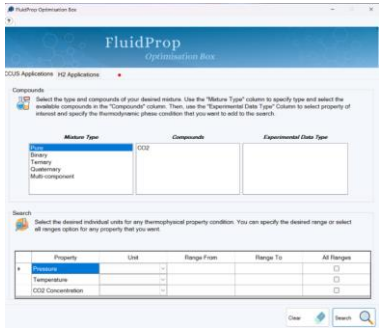
Flow Assurance problems! (i.e. Corrosion)



Errors in H_2 flow measurement!

Optimisation of PVT Models

Firstly, we have used massive experimental datasets from our partner for optimisation of equations of state.



Uncertainty analysis and quantification of each model prior to the optimisation…

After optimisation of model parameters, then the models are ready to be used for the reliable generation of thermophysical properties…

Experimental Facility Description

- A new and unique **thermophysical properties test rig at NEL** was employed for **density** and **speed of sound** measurements.

Item	Operating Range	Unit
Pressure	0.1 to 400	bar
Temperature	-5 to 65	°C

Experimental Materials and Conditions

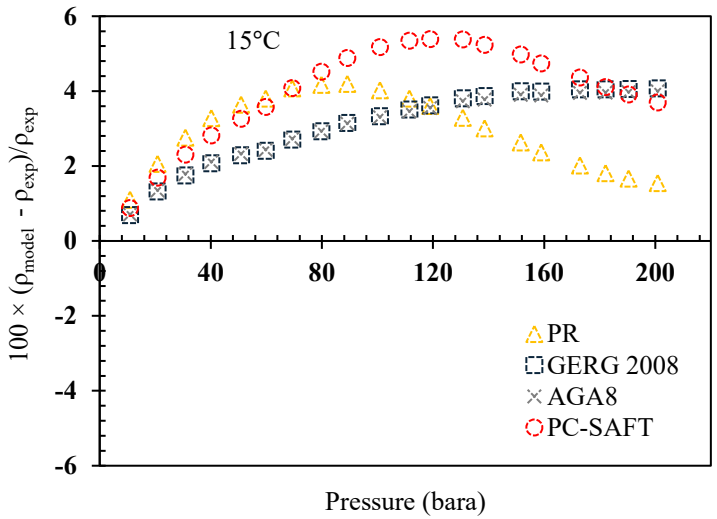
Pressure range: 10 to 200 bara

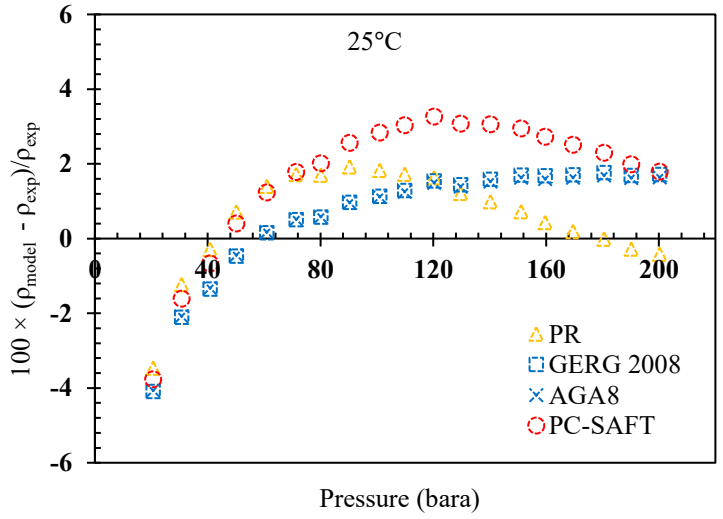
Temperature range: 15°C, 25 °C, and 45 °C

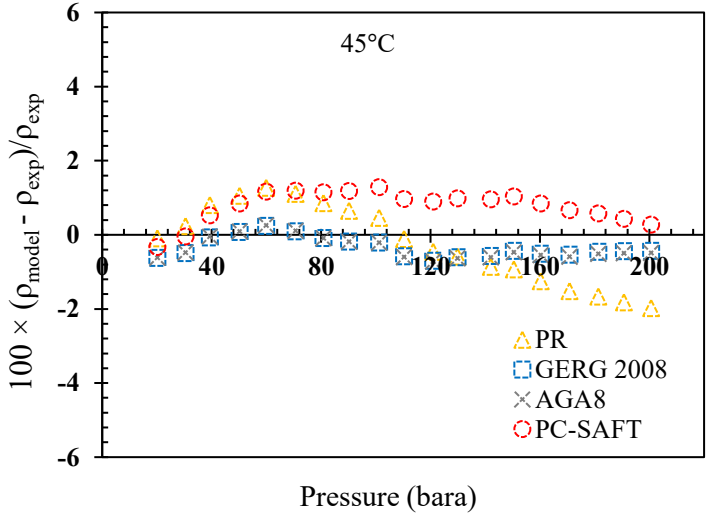
Molar composition of H_2-enriched natural gas used in this study *(5% H_2-enriched NG)*

Component	CAS Number	Mole fraction
H_2	1333-74-0	**0.05**
N_2	7727-37-9	**0.01425**
CO_2	124-38-9	**0.019**
CH_4	74-82-8	**0.836**
C_2H_6	74-84-0	**0.057**
C_3H_8	74-98-6	**0.019**
n-C_4H_{10}	106-97-8	**0.00285**
Iso-C_4H_{10}	75-28-5	**0.0019**

Thermodynamic Modelling
Density Relative Deviation







5% H_2-enriched NG

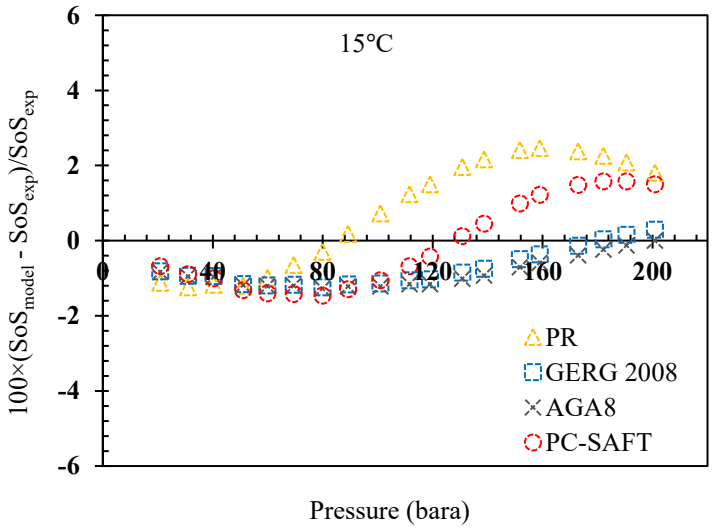
system: H_2+N_2+CO_2+CH_4+C_2H_6+C_3H_8+n-C_4H_{10}+iso-C_4H_{10}

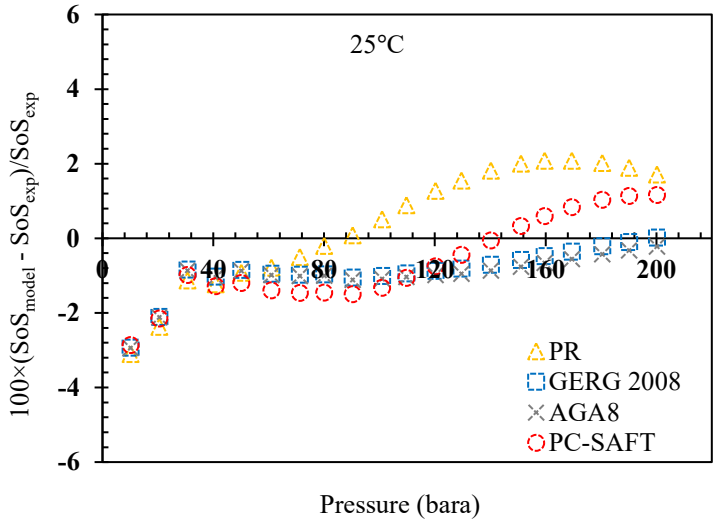
Pressure range: 10 to 200 bara

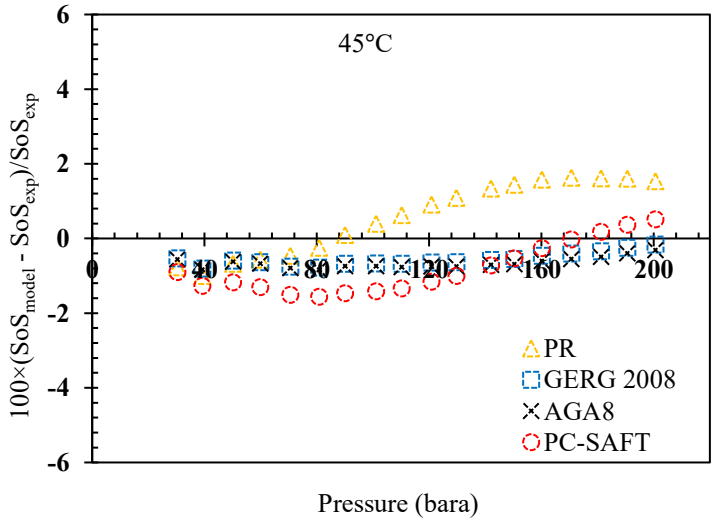
Temperature range: 15°C, 25 °C, and 45 °C

Equation of state	average absolute relative deviation(%)		
	15°C	25°C	45°C
PR	**2.94**	**1.15**	0.93
GERG-2008	3.09	1.44	**0.39**
AGA8	3.05	1.40	**0.41**
PC-SAFT	4.02	2.29	**0.81**

Thermodynamic Modelling
Speed of Sound Relative Deviation







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system: H_2+N_2+CO_2+CH_4+C_2H_6+C_3H_8+n-C_4H_{10}+iso-C_4H_{10}

pressure range: 10 to 200 bara

Temperature range: 15°C, 25 °C, and 45 °C

Equation of state	average absolute relative deviation(%)		
	15°C	25°C	45°C
PR	1.47	1.41	0.97
GERG-2008	**0.79**	**0.89**	**0.57**
AGA8	**0.86**	**0.99**	**0.66**
PC-SAFT	**1.08**	**1.15**	**0.93**

Conclusions

1. **Measuring thermophysical properties** of H_2-enriched NG streams

2. Assessing the accuracy and reliability of four equations of state: PR, GERG-2008, AGA8, and PC-SAFT EoSs

3. Presenting the efficacy of **AGA8**, **GERG-2008**, and **PC-SAFT** n accurately and reliably predicting the thermophysical properties

4. Improving the **fluid model parameters** and fine-tuning them using **innovative methods** is the focus of our ongoing research

Here Meet Our Dedicated Team

Thanks for your attention!

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