Thermophysical Properties of Hydrogen Enriched Natural Gas

Dr. Xiong Xiao* Ms Gwen Sellner Dr. Saif Al Ghafri A/Prof. Paul Stanwix

*presenter (xiong.xiao@uwa.edu.au)

FUTURE ENERGY EXPORTS
Cooperative Research Centre

Project aims

Hydrogen-enriched natural gas (HENG), a mixture of hydrogen and natural gas, addresses the issues of decarbonization and improved energy management. To confidently design and operate HENG gas pipelines and processing facilities, a deep understanding of thermophysical property data is required. This project aims to critically evaluate the quality of thermophysical property data in the literature, offer valuable insight into the available models, provide initial parameter regression for improvement, find the gap between the industrial need and the existing data, and suggest the potential future measurement work.

Methods

An extensive literature search was performed to collate the available data of HENG mixtures in fluid phases. Data quality from different sources was assessed by considering the experimental method, claimed uncertainty, and deviations from other relevant data and models. Three thermodynamic models (AGA8-DC92[1], GERG-2008[2], and Beckmüller et al.[3]) and one transport property model (Extended Corresponding States (ECS)[4, 5]) were compared to the data. An initial parameter regression to existing data will be conducted in REFPROP via least-square fitting procedure, with the results implemented in HYSYS via CAPE-OPEN. This review will identify areas where additional thermophysical property data is required and the experimental conditions for future experimental studies (temperature, pressure, and composition) and model development.

Table 1 Summary of the models reviewed in this work

Model	Temperature Range (K)		Pressure Range (MPa)		Normal Range Uncertainty	
	Normal	Extended	Normal	Extended	ρ	w
AGA8-DC92	250-350	143-673	<30	<280	0.1%	0.2%
GERG-2008	90-450	60-700	<35	<70	0.1%	0.1%
Beckmüller et al.	90-450	60-700	<35	<70	0.1%	0.1%
Model	**Temperature Range (K)**		**Pressure Range (MPa)**		**Normal Range Uncertainty**	
					η	λ
REPROP ECS	-	-	-	-	5-10%	-

Results

The review has initially focussed on the binary mixture of hydrogen and methane. Figures 1 and 3 exhibit deviation plots for available density and viscosity data. The Beckmüller model is able to describe most of the density data within a few percent, with deviations generally increasing below 200 K and for older data acquired using the Burnett technique.

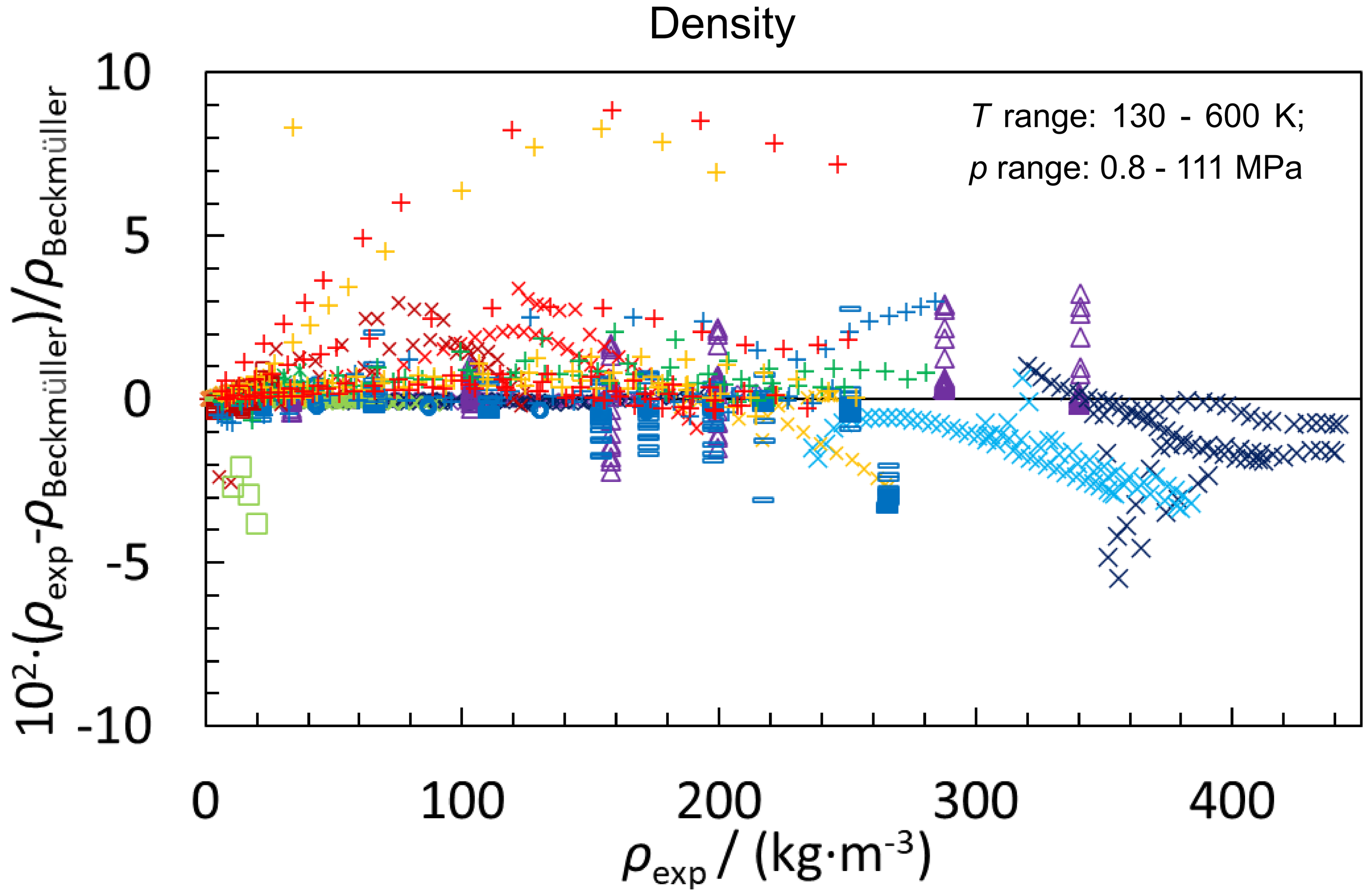


Figure 1 Deviation plot for mixture density and compressibility (converted to density) data with respect to the Beckmüller et al. model.

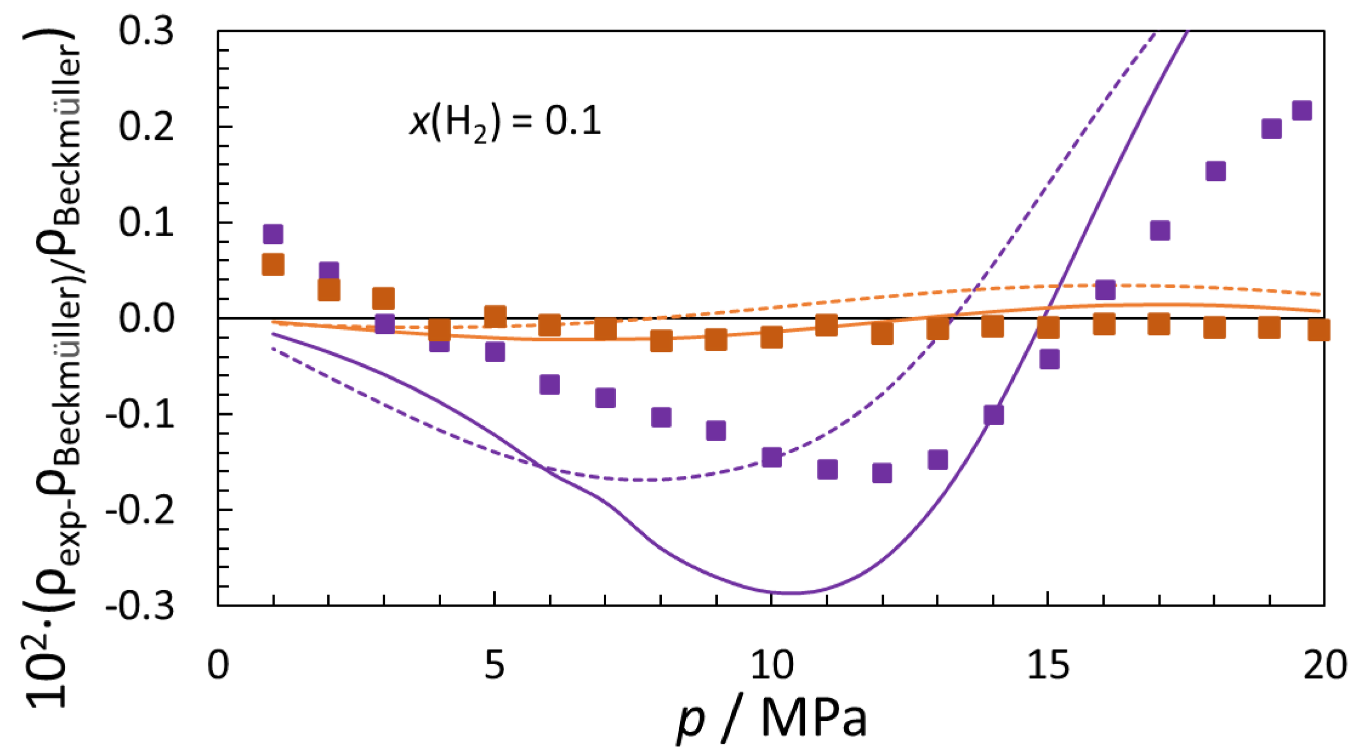


Figure 2 Select recent density data,[6] measured using a magnetic suspension balance densimeter. The predictions of three density models are compared.

Limited data are available for viscosity (five sources) with large systematic deviations from the ECS model (calculated using REFPROP).

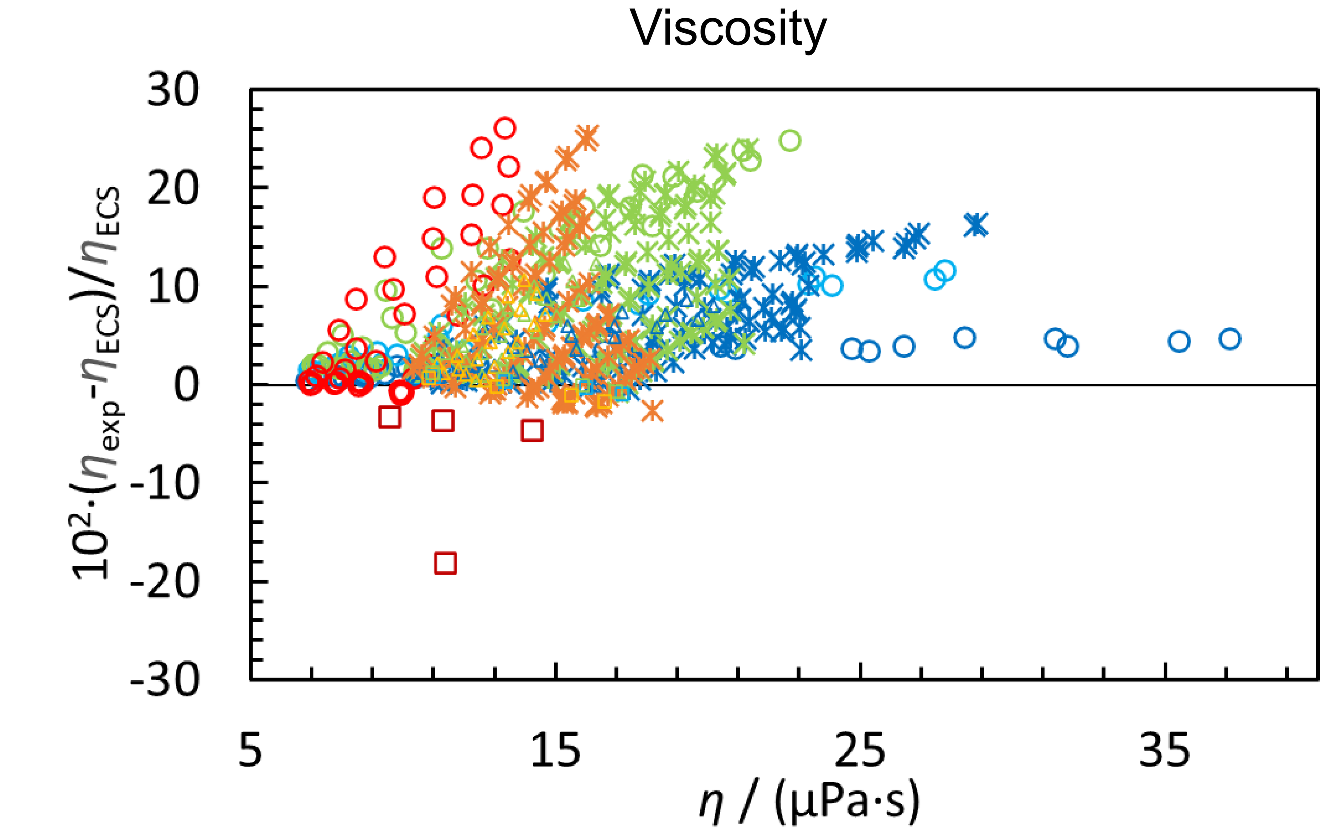
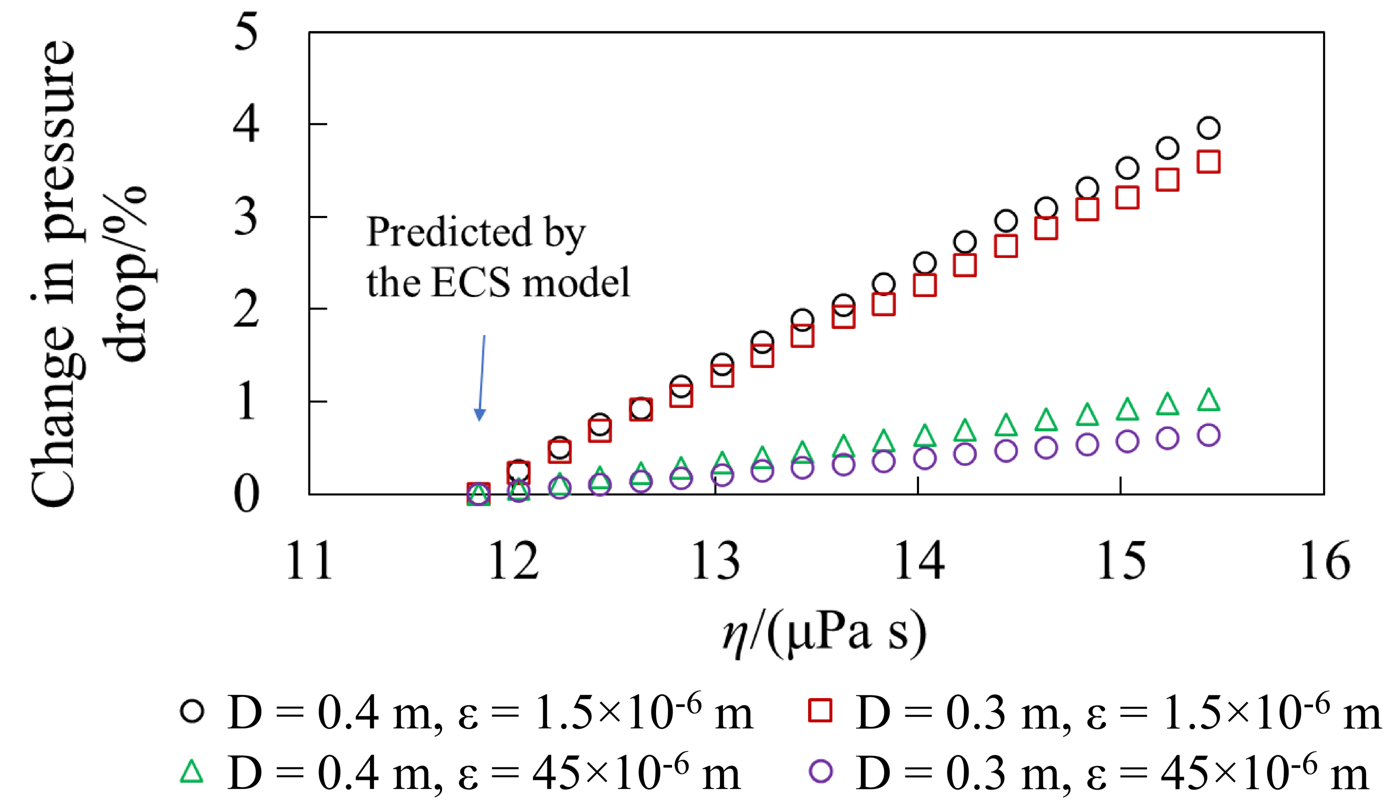


Figure 3 Deviation plot for mixture viscosity with respect to the ECS model.

Impact

Based on the range of viscosity deviation (up to 30%), pressure drop calculations were performed to investigate the effect for a simple pipeline.

Conditions: a 25 km length pipe of 15% H_2 + 85% CH_4 at (300 K, 50 bar), 20 Nm^3/s



Method: Darcy-Weisbach equation[7] based on recommended pipe dimensions[8] and materials (pipe roughness (ε): PVC pipes (1.5×10^{-6} m), steel pipes (45×10^{-6}))

Partners

wood. INPEX

References

1. Starling, K. E.; Savidge, J. L., American Gas Association, Operating Section: 1992.
2. Kunz, O.; Wagner, W., J. Chem. Eng. Data 2012, 57, 3032-3091.
3. Beckmüller, R.; Thol, M.; et al. Phys. Chem. Ref. Data, 2021, 50, 013102.
4. Ely, J. F.; Hanley, H. J. M., Ind. Eng. Chem. Fundam. 1981, 20, 323-332.
5. Ely, J. F.; Hanley, H. J. M., Ind. Eng. Chem. Fundam. 1983, 22, 90-97.
6. Hernandez-Gomez, R.; et al., J. Chem. Eng. Data. 2018, 63 (5), 1613-1630.
7. Jones, G. M; et al., Pumping station design. Gulf Professional Publishing: 2006.
8. Lu, Y.; Pesch, T.; Benigni, A.,. Energies 2021, 14 (22), 7680.