Bioenergy Research at The University of Glasgow

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Introduction

• Combustion, Gasification and Modelling
  Systems power and Energy, School of Engineering

• Algae Research
  Systems power and Energy, School of Engineering

• Grassland Biomass and Management
  School of Geographical and Earth Sciences
Real time control of gasification processes to increase tolerance to biomass variety and reduce emissions

EPSRC SUPERGEN Bioenergy Challenge II
March 2\textsuperscript{nd} 2015 – August 2018 (Overview https://vimeo.com/111747720)

Aims
• To investigate the effect of biomass harvest and pretreatment variables on gasification efficiency and output greenhouse gas and particulates
• To develop robust, inexpensive control systems to broaden the scope of biomass input into the system, reduce tar formation and optimize the syngas quality.

Scope
• Development of gasification systems (Glasgow/Aston))
• Modelling gasification processes (Glasgow/Aston)
• Real time control and instrumentation of gasification system (Glasgow/Aston)
• Robust and inexpensive tar detection system (Glasgow/Aston)
• Assess impact of biomass variety and pre-treatment (Aberystwyth)
• Techno-economic analysis and Life Cycle Assessment (LCA) (Manchester)
Real time control of gasification processes to increase tolerance to biomass variety and reduce emissions

University of Glasgow: Ian Watson (PI), James Sharp, Nader Karimi, Manosh Paul, Zhibin Yu, Peter Hastie, Paul Younger, Zakir Khan

Aston University: Tony Bridgwater, Paula Blanco, Xi Yu

Aberystwyth University: Iain Donnison, Jon McCalmont, John Corton

Manchester University: Paul Gilbert

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System Power and Energy
Combustion modelling of single biomass particle in different gas atmospheres

Comparison of simulated and measured particle temperatures

Distribution of H₂ during combustion process of biomass Bagasse

NOx PPM for biomass Bagasse at 100 ms after particle release.

Case 3: 37% O₂ & 63% N₂

Case 5: 100% O₂
CombGEN is a network of applied researchers and industrialists with shared interests in cleaner and more efficient combustion and gasification technologies, providing a strong platform for sharing techniques, software and technologies, and ensuring their timely transfer to industrial applications.

http://www.combgen.gla.ac.uk/
Kinetic modelling of downdraft biomass gasification

- Model integrates drying, pyrolysis, oxidation and reduction of a gasifier.
- Thermochemical kinetics of relevant reactions at each zone are included.
- Model tested in a downdraft gasifier with various biomass feedstocks.
- Shown below one example of the syngas compositions produced from rubber wood biomass.

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CFD Modelling

Preliminary CFD Modelling results of biomass gasification

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Systems Power and Energy
Partners: University of Strathclyde, Robert Gordon University, University of the West Scotland and 6 industries
Grassland biomass and management
Dr Brian Barrett
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Barrett, B. (PI) et al. - Grassland management and biomass retrieval in an intensive dairy farm in Ireland using TerraSAR-X Staring Spotlight mode data (German Aerospace Center (DLR) (TSX-New Modes-2013) ID: LAN2381).
Barrett, B. (PI) et al. - Monitoring Grasslands using Polarimetric Radarsat-2 data (Canadian Space Agency (CSA) and European Space Agency (ESA) SOAR-EU2 proposal (ID: 16753)
Microalgae research

Real time detection and optimised growth

Scaling strategies...
Microalgae research
Dewatering, Lysing and Extraction

Solvent extraction
Pyrolysis, gasification and hydrothermal liquefaction of microalgae

Dewatering, vacuum filtration, centrifugation

Algal cell disruption:
Microwave, waterbath, blender, ultrasonic and laser treatment

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System Power and Energy
Advanced Processes

- Manufacturing of complex systems
e.g. thermally harsh environments, cryogenic, vacuum, high pressure, laser and plasma systems…
- Laser combustion
- Microwave biomass pre-treatment
- Microwave and Solar-assisted gasification

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Dr Manosh Paul

EPSRC
Engineering and Physical Sciences Research Council

SUPERGEN Bioenergy Hub
Conclusion

- Experience of building complex systems
- Instrumentation and data capture
- From biomass pre-treatment to useful energy
- Gasification, combustion
- Modelling
- Grassland biomass and management
- Microalgae from growing, harvesting and extraction
- Advanced processes – laser, plasma, microwave, solar…