A gasifier test bed for analysing on-line tar detection and control systems for enhanced gasification performance

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Problem, potential solutions and strategy

Tar formation
- Operate on the minimum tar production point
- Need a tar detection system
- Must be robust and inexpensive

Biomass variety
- Feedstock
- Blending
- Pretreatment

Real time control
- Inexpensive, robust

LCA, Techno-economic analysis
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Real time control of gasification processes to increase tolerance to biomass variety and reduce emissions

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Aims
• To investigate the effect of biomass harvest and pretreatment variables on gasification efficiency and output greenhouse gas and particulates
• To develop 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)
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Industrial support:
**Uniper**  
**gf consulting**  
**Downhole Energy**
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Gasification System
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Gasification System

Data monitoring and control
Gasifier and hot gas filter
Space for tar detection
Condenser
Gas flowmeter
Tar collection
Exhaust
Gas analyser
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Gas Composition

ER = 0.30

Gas Composition (%)

Time


CH4 (%) CO (%) CO2 (%) O2 (%) H2 (%) N2 (%)
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Tar Detection-Fluorescence

Phenol and Bio-oil detection (Liquid phase, offline)

- Phenol sample in cuvette
- Long pass filter
- LED
- PMT
- Water Sample

Graphs showing the relationship between sample phenol concentration and photomultiplier output voltage, and the percentage of gasifier oil in a sample and photomultiplier output voltage.
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Tar Detection-Fluorescence
Online Tar Detection System (Gas phase)
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Instrumentation and Control

Optimus Prime: Version 1 (Present)
1) Three 20*4 Character LCD

Optimus Prime: Version 2 (Progressing)
1) Touch Screen
2) Sensors: 12-thermocouple, 2-weight load, 1-airflow, 1-Mass flow controller, 1-liquid flow, 2-Pressure,
   Controlling through mobile or Wi-Fi.
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Gasification Temperature Profile (ER 0.30)
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Gasification Temperature Profile (ER 0.25)
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Arduino based mass (air) flow sensor (ER 0.25)
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What next? Automatic Control System

- K-type thermocouple with Max31855 amplifier (Tempcon, -200 to +1350 °C)
- Liquid flow sensor (Sourceing, 1-30 L/min)
- Air flow sensor (Sourceing, -200 to +200 L/min)
- Pressure Sensor (Eldor, 0 to 1.2 MPa)
- Debugging screen with HD44780 (Gaoxing Tech., 20*4)
- Microcontroller Arduino Mega ADK
- Weight sensor with HX711 amplifier (Seedstudio, 0 to 50Kg)
- Heating tape Control
- Gas Analyser
- Red-Y Air flow controller
Conclusion

- Instrumentation completed
- Data logging completed
- Control strategy developed
- Experiments on feedstock and output fluctuations in progress
- System errors
- Tar detection system assembled and being calibrated against tar standards