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Engineering and Physical Sciences Research Council

University of Glasgow | College of Science & Engineering

Supergen Bioenergy

Real-time tar detection and control of a gasifier test bed system at the University of Glasgow – Glasgow's downdraft gasification test-bed system

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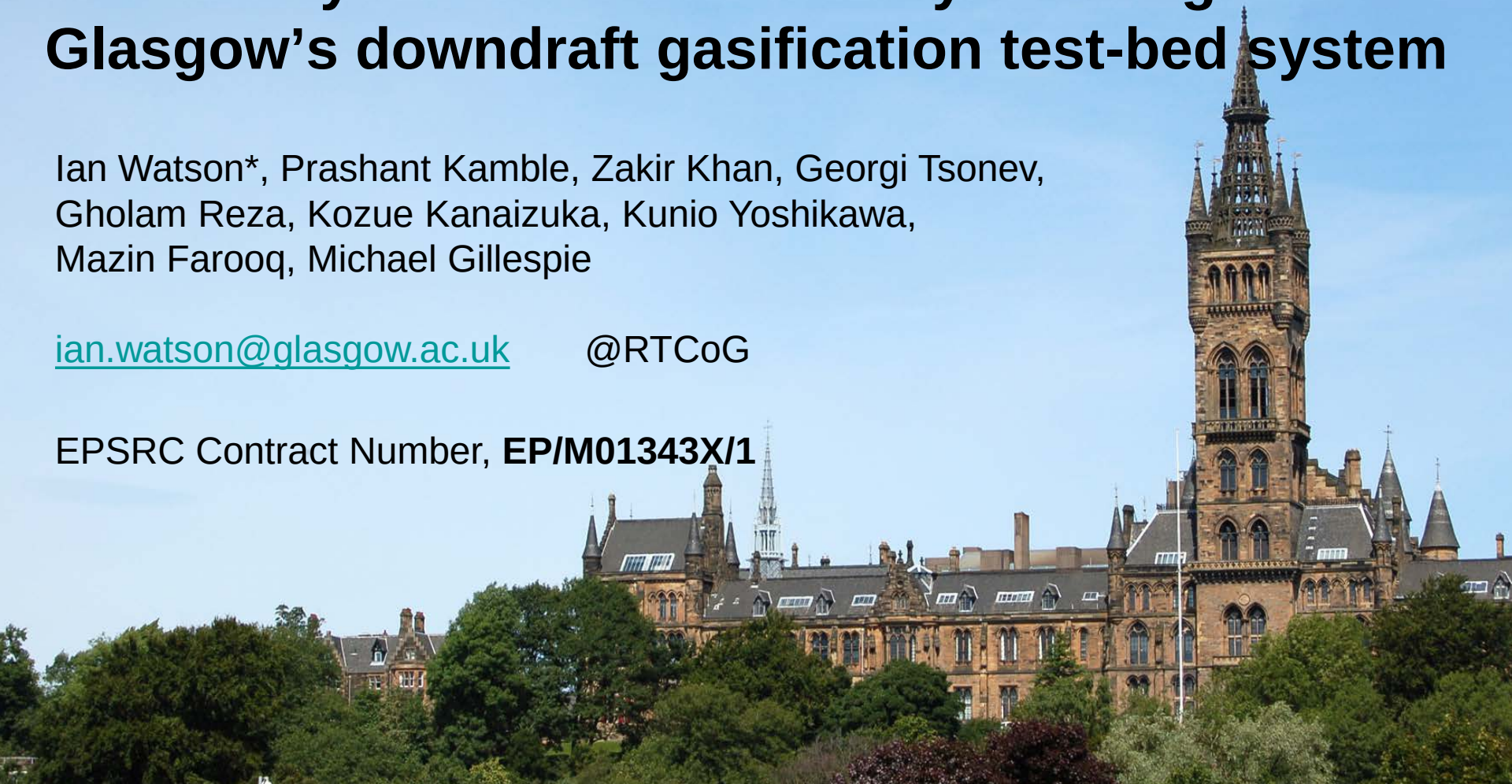


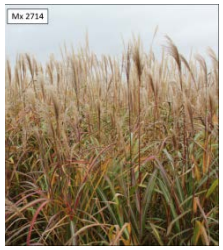
Contents

Real-time tar detection and control of Glasgow's downdraft gasification test-bed system

Problem, potential solutions and strategy

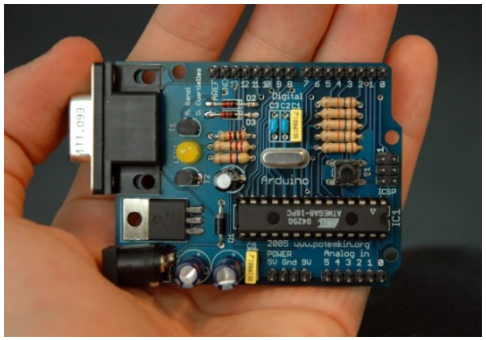
Tar formation

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

Real time control of gasification processes to increase tolerance to biomass variety and reduce emissions

EPSRC SUPERGEN Bioenergy Challenge II
March 2nd 2015 – August 2018

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

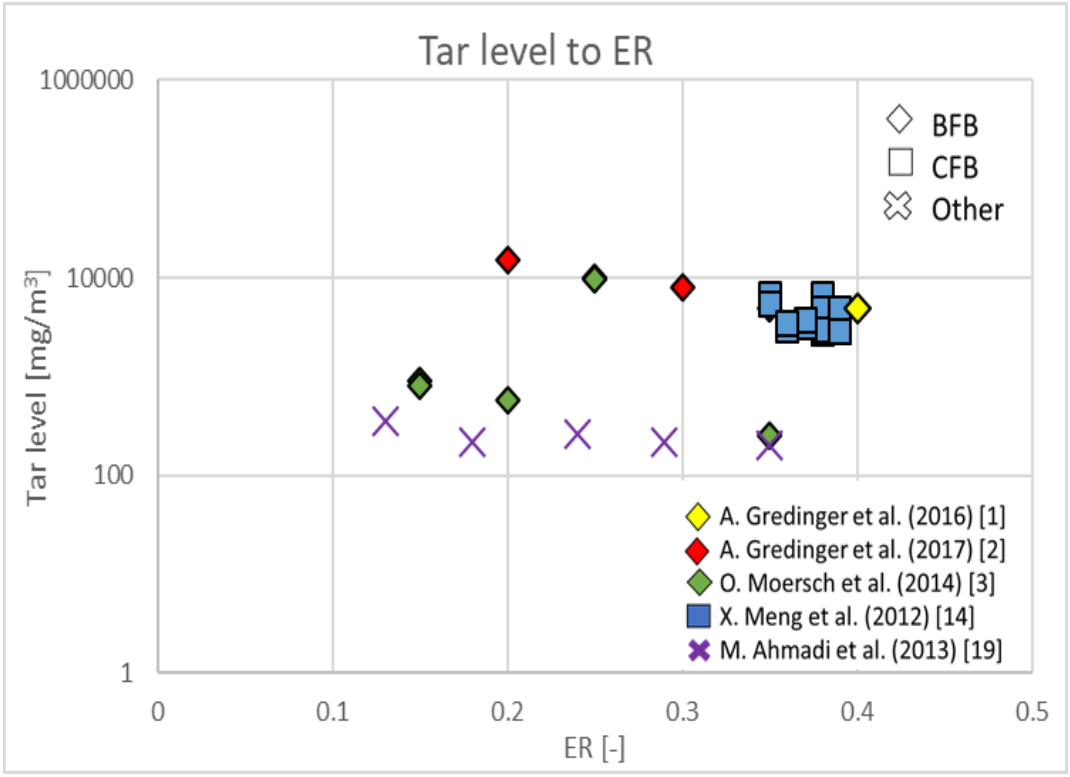
- Development of gasification systems (Glasgow/Aston))
- Modelling gasification processes (Glasgow/Aston)
- Real time control and instrumentation of gasification system (Glasgow/Aston)
- Robust and inexpensive tar detection system (Glasgow/Aston)
- Assess impact of biomass variety and pre-treatment (Aberystwyth)
- Techno-economic analysis and Life cycle assessment (LCA) (Manchester)

Real-time tar detection and control of Glasgow's downdraft gasification test-bed system

Academic:
University of Glasgow: Ian Watson, Zakir Khan, Prashant Kamble, Michael Gillespie, Mazin Farooq, James Sharp, Nader Karimi, Manosh Paul, Zhibin Yu, Peter Hastie, Paul Younger,
Aston University: Tony Bridgwater, Paula Blanco, Xi Yu
Aberystwyth University: Iain Donnison, Jon McCalmont, John Corton
Manchester University: Amanda Lea-Langton, Paul Gilbert, Chen-wei Chang, Zhongyuan Li

Industrial support:
Uniper gf consulting, Downhole Energy.

Tar levels as a function of ER



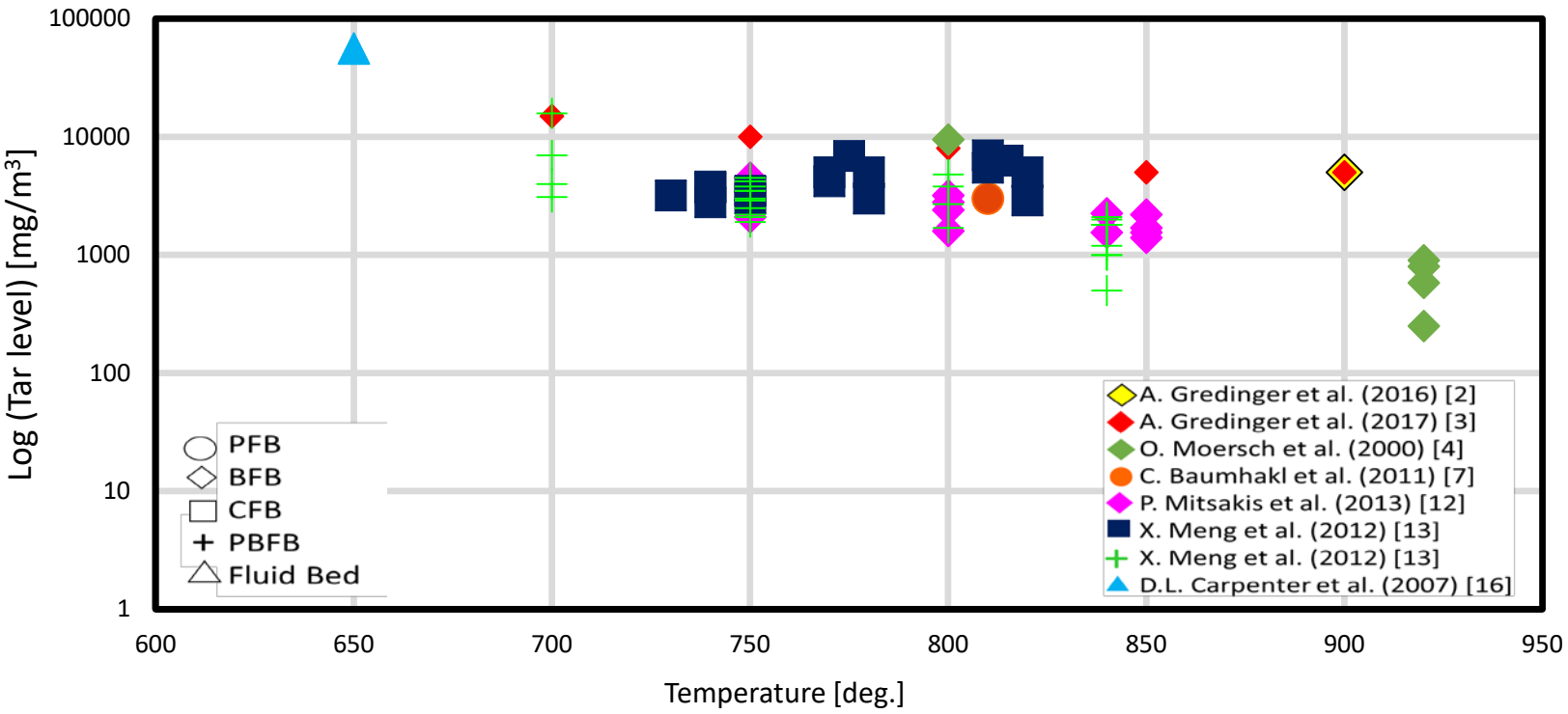
PFB : Pressurized fluidized bed

BFB : Bubbling fluidized bed

CFB : Circulating fluidized bed

PBFP : Pressurized bubbling fluidized bed

Tar levels as a function of temperature

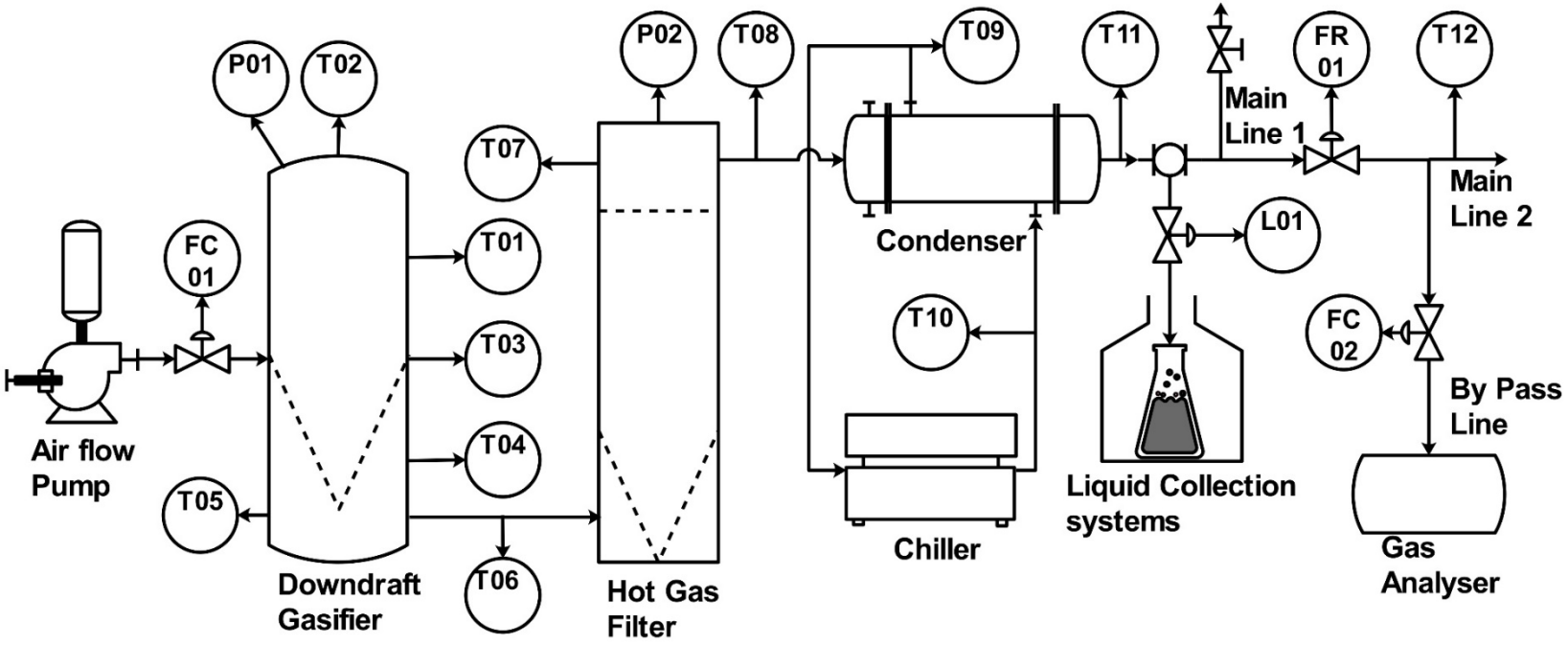


PFB : Pressurized fluidized bed, BFB : Bubbling fluidized bed,

CFB : Circulating fluidized bed, PBFP : Pressurized bubbling fluidized bed

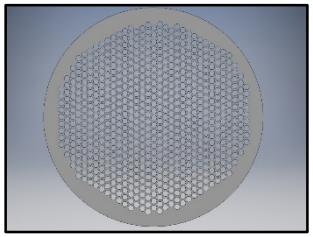
Real-time tar detection and control of Glasgow's downdraft gasification test-bed system

Gasification System

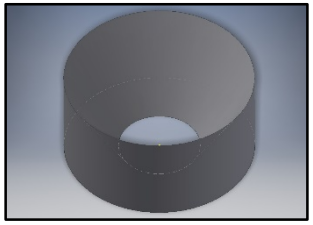


Real-time tar detection and control of Glasgow's downdraft gasification test-bed system

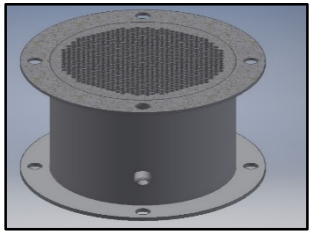
Downdraft Throated Gasifier (~3.5 kW)



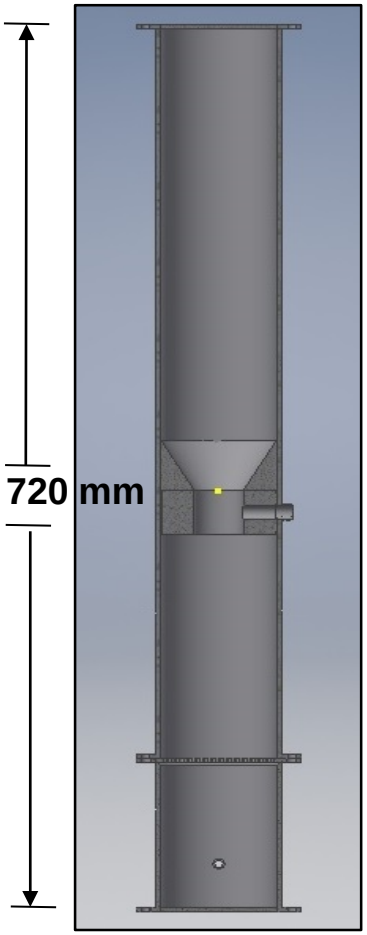
Mesh



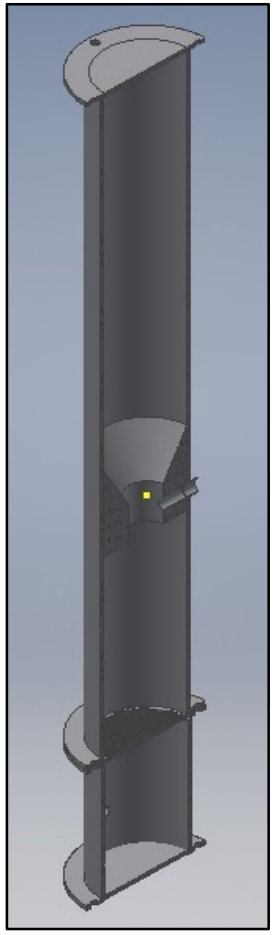
Throat

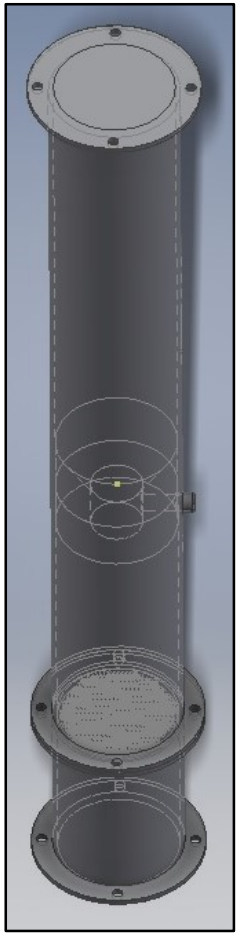


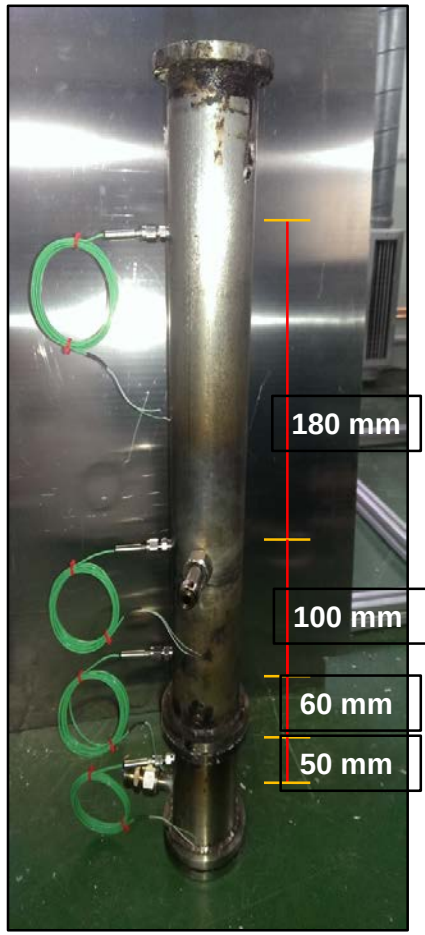
Bottom section



70 mm (ID)







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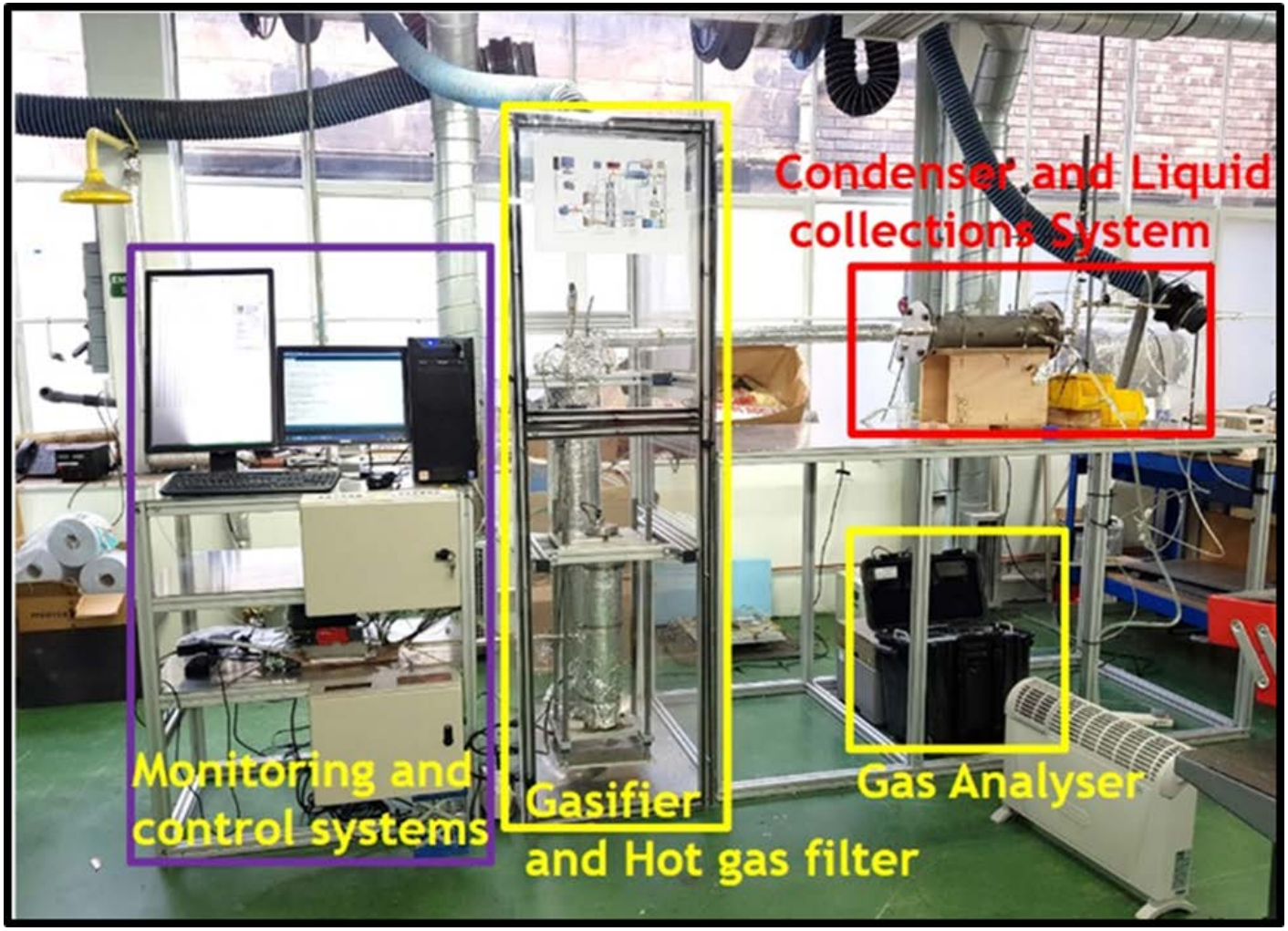
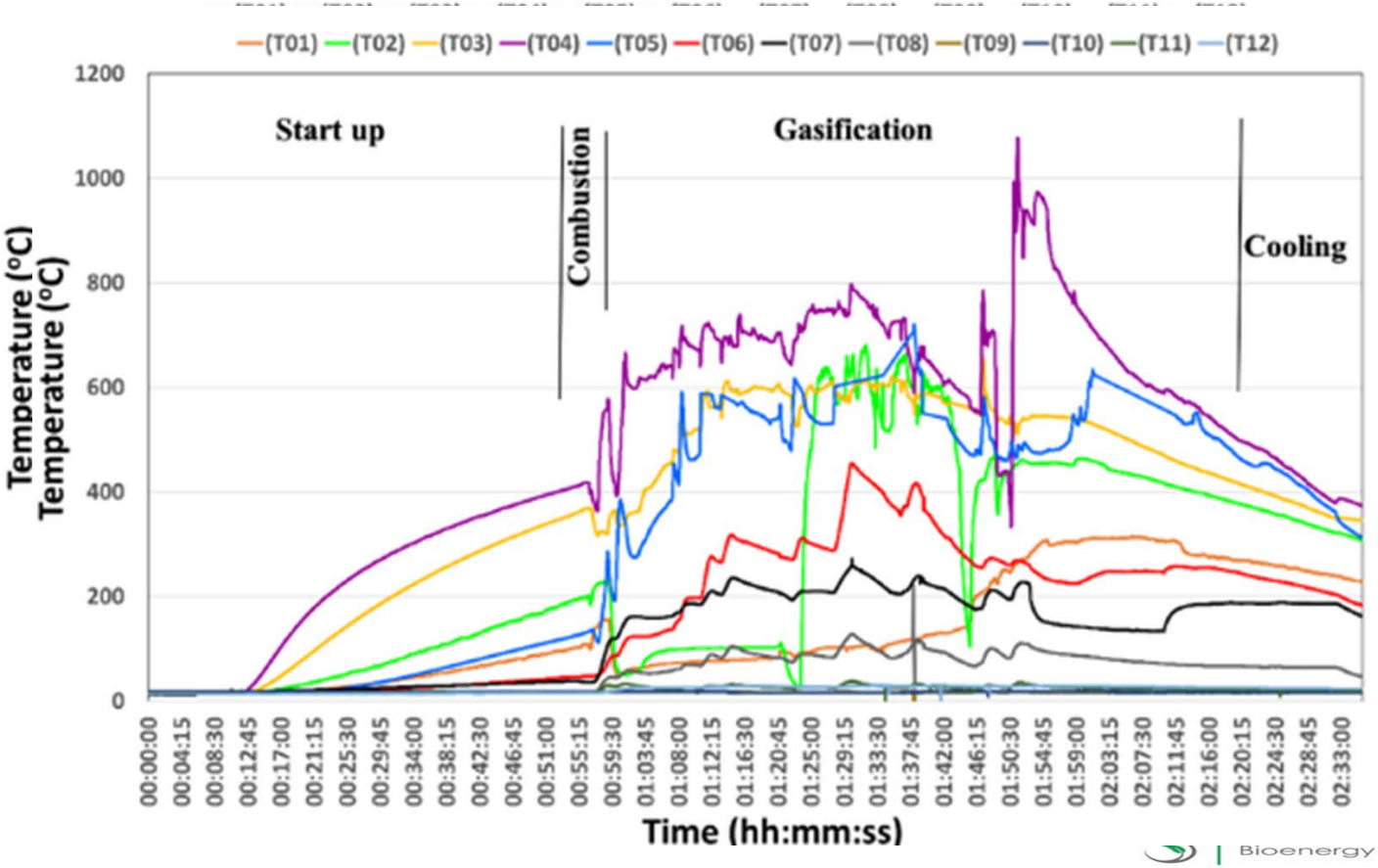
Improving biomass gasification through tar detection and gasifier control

Laboratory set up



5. Experimental results [*Miscanthus* (Mx2717) E.R 0.30]

Temperature profile

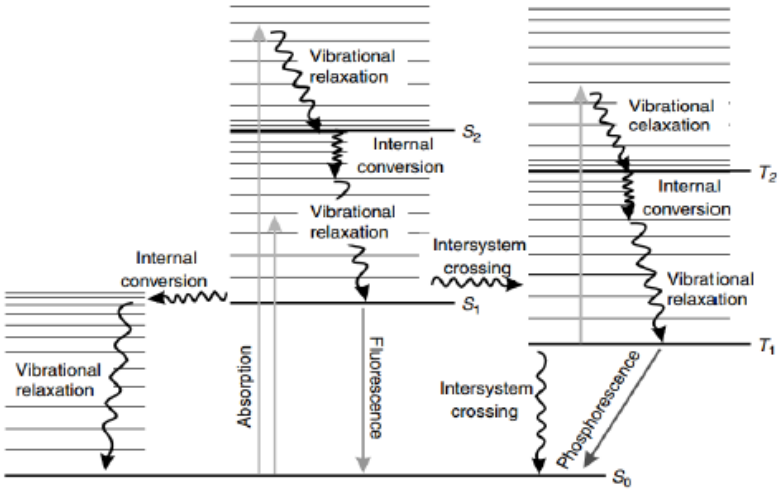


Tar Detection Methods

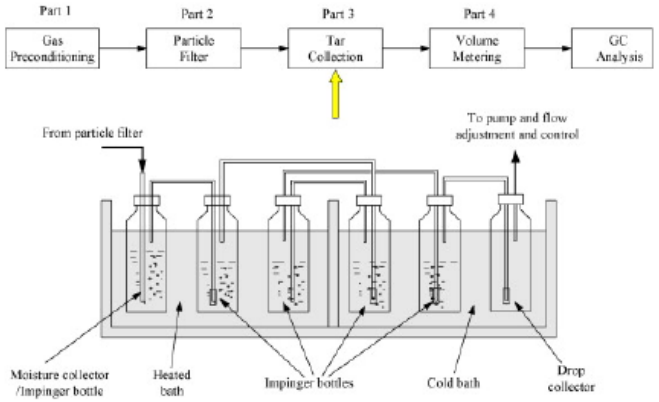
Fluorescence

Flame colour analysis

Calibrate with:
European Tar Protocol
GCMS



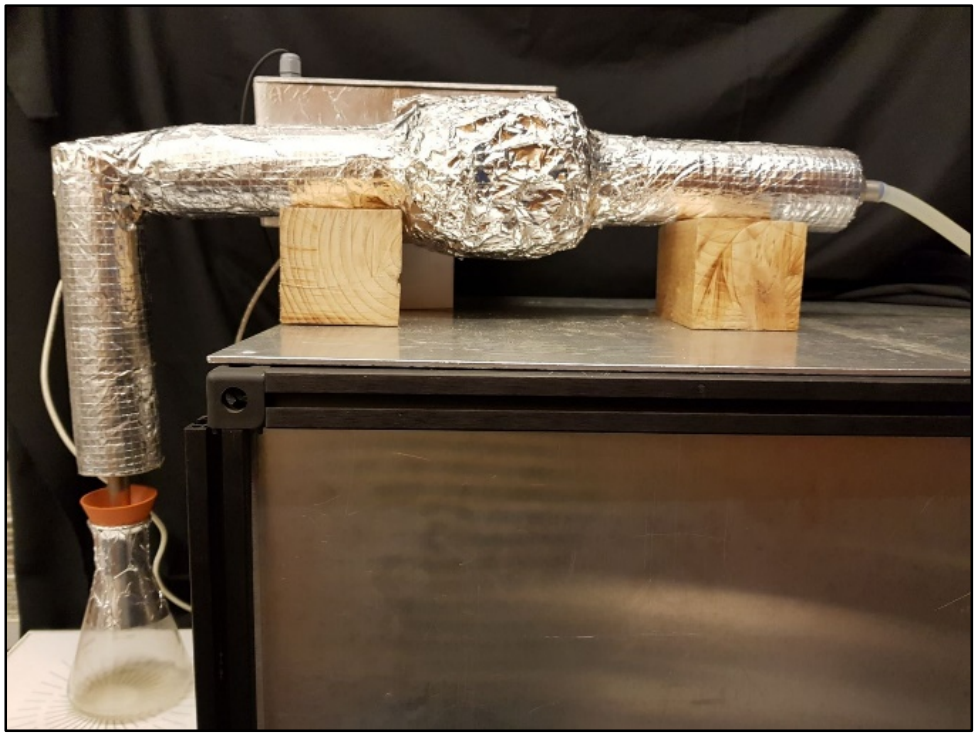
· *Jablonski Diagram of molecule transitions (Sauer, Hofkens, & Enderlein, 2011)*

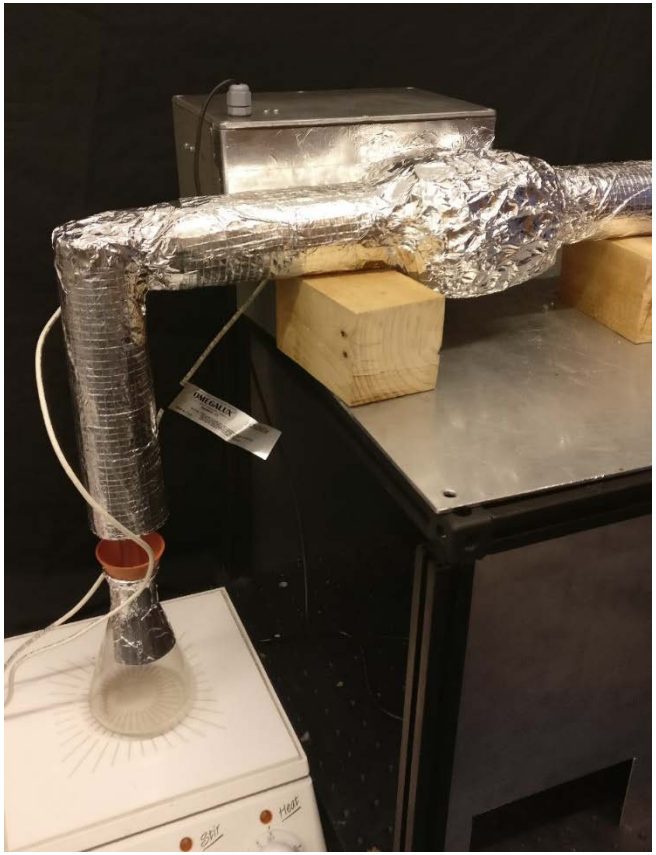


· *Chain of Impinger Bottles (Chunshan & Kenzi, 2008)*

Tar Detection-Fluorescence

Online Tar Detection System, calibration (Gas phase)





Tar Detection-Fluorescence

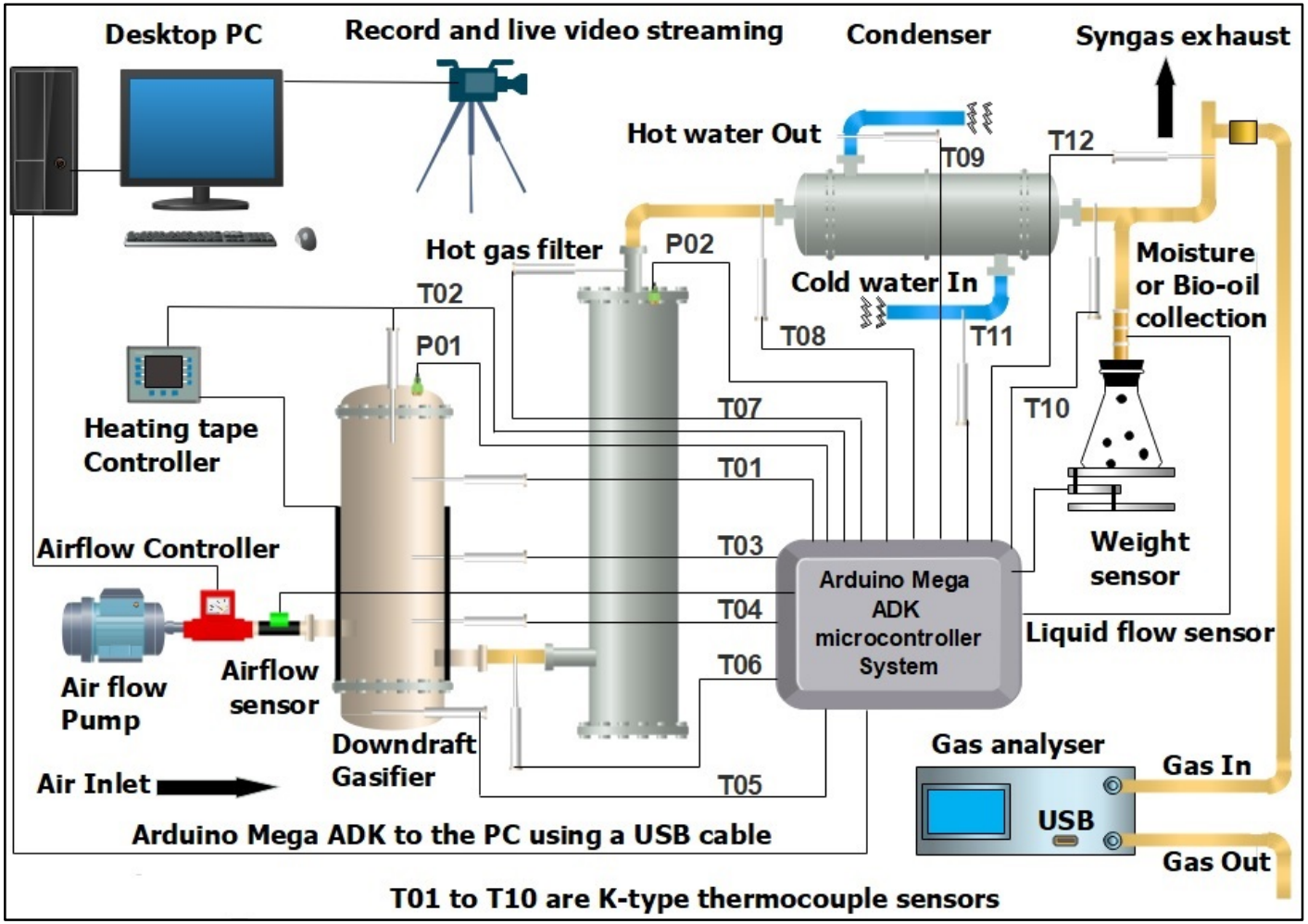
Online Tar Detection System connected to gas flow by-pass

Tar Detection-Fluorescence

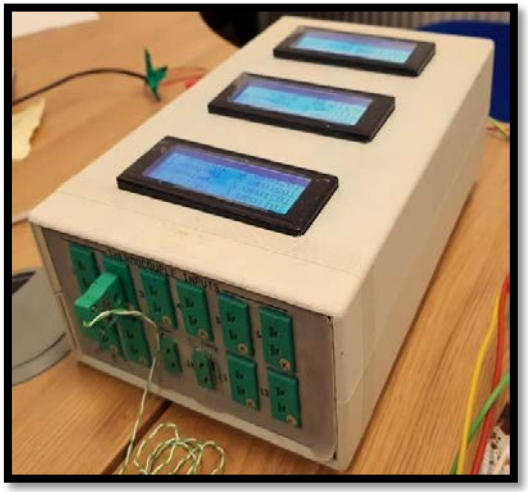
Online Tar Detection System, heating pads (Gas phase)

Real-time tar detection and control of Glasgow's downdraft gasification test-bed system

Instrumentation and Control

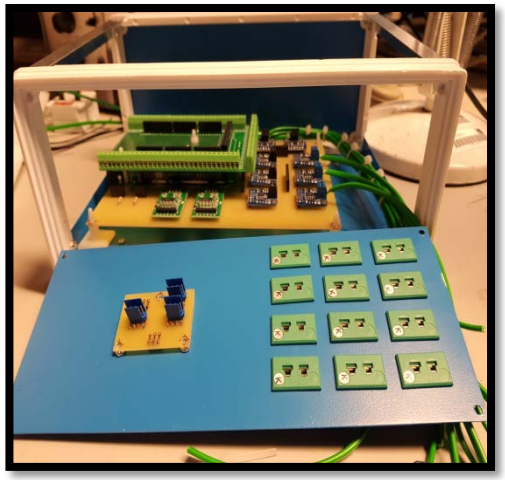


Instrumentation and Control



Version 1 (Present)

1) Three 20*4 Character LCD
2) Sensors: 12-thermocouple, 1- weight load, 1-airflow, 1-liquid flow, 1-Pressure.

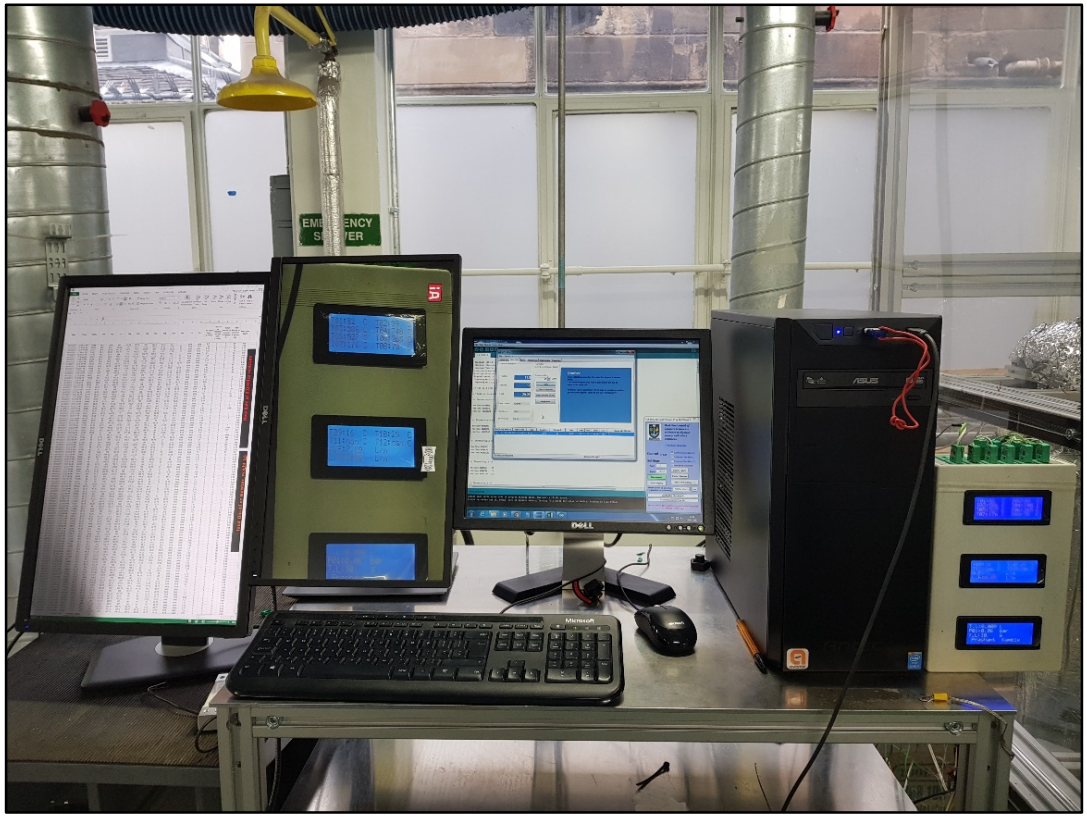


Version 2 (now completed)

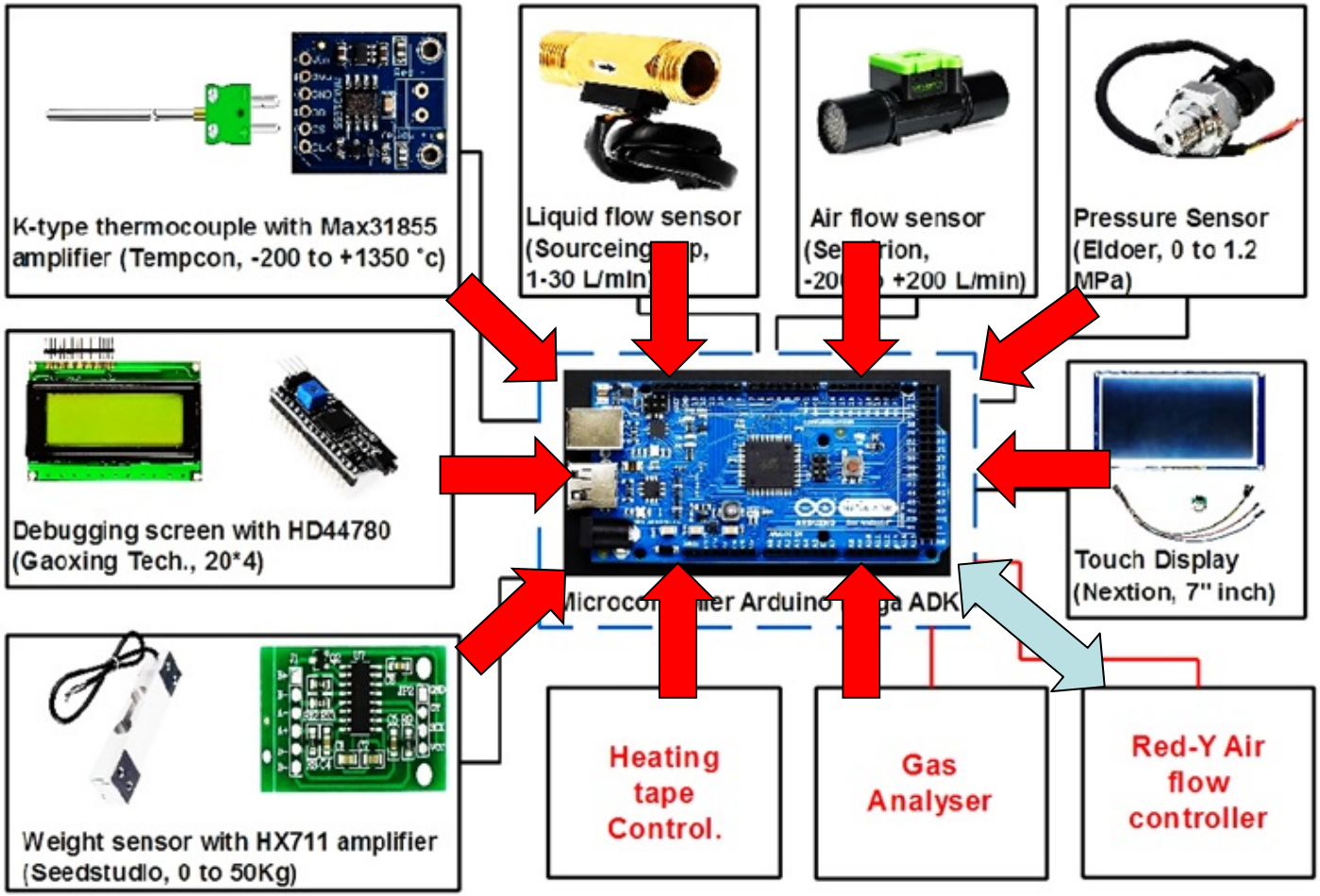
1) Touch Screen
2) Sensors: 12-thermocouple, 2-weight load, 1-airflow, 1-Mass flow controller, 1-liquid flow, 2-Pressure,

Controlling through mobile or Wi-Fi.

Real time data collection and graph plotting in Microsoft excel



Automatic Control System



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 and on gasification of biomass