Center for Applied Energy Research

Modular Staged OMB Gasification Technology (DE-FE00031506)

Kunlei Liu, Landon Caudill and Zhongjie Shen

University of Kentucky

Center for Applied Energy Research

Lexington, KY

https://caer.uky.edu/power-generation/

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Project Overview

- **Project Title:** Staged OMB for Modular Gasifier/Burner
- **Project Start Date:** December 1, 2017
- **Scheduled Duration:** 3 years
- **Single Budget Period:** $2,016,192
- **Project Partners:**
  - East China University of S&T
  - Trimeric

Budget Period	Performing Organization	Planned Costs		
		Federal Share	Non-Federal Share	Total
1	UKRF	$1,415,308	$385,884	$1,801,192
1	ECUST	$72,000	$18,000	$90,000
1	Trimeric	$125,000	$0	$125,000

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ECUST

Trimeric Corp.

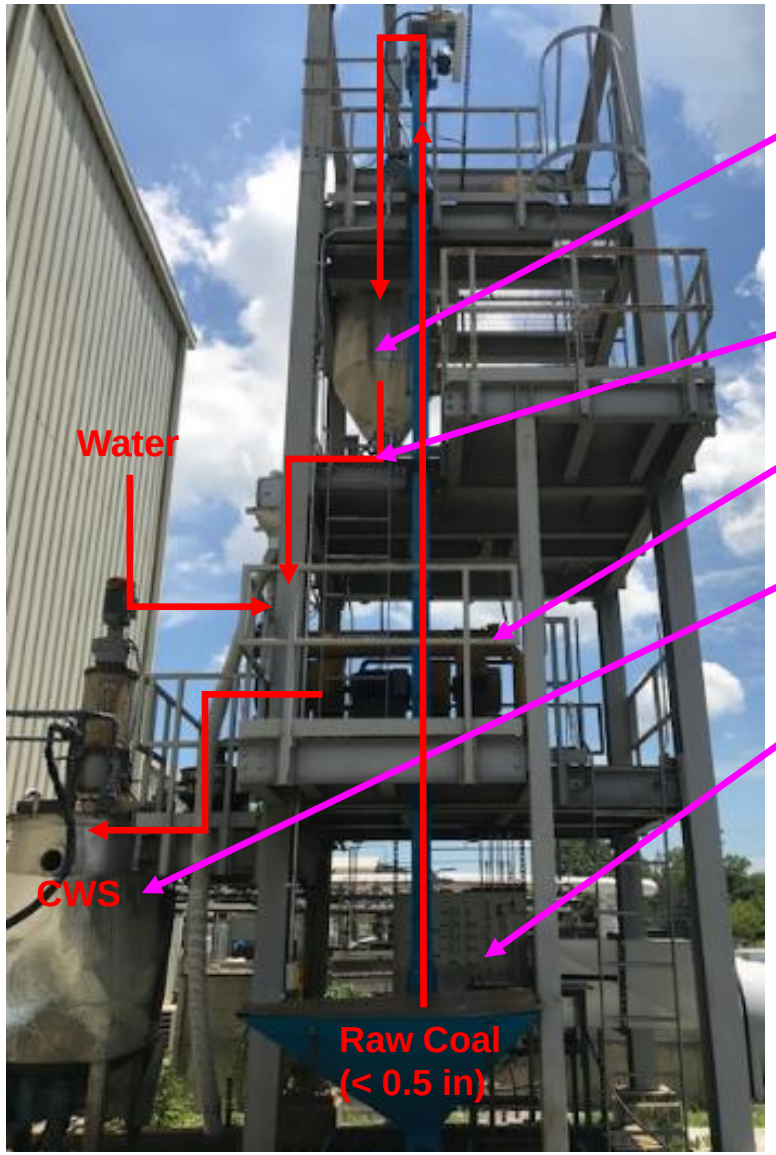
Project Objectives & Task List

Objective:

- Modularize gasifier and standardize the burner design with a focus on modularization.
- Investigate the effect of water quench on gas composition, such as the increase in H_2 due to the water gas shift (WGS) reaction.
- Modify UK CAER's 1 TPD coal OMB gasifier to form a staged gasification simply by replacing the existing camera monitor with a burner at the top of the gasifier.

- **Task 1:** Project Management and Planning
- **Task 2:** Construction of the Staged-OMB Gasifier
- **Task 3:** Parametric Study of Staged-OMB
- **Task 4:** Fuel Flexibility with Fuel Blend
- **Task 5:** In-situ Water Gas Shift (WGS) Development
- **Task 6:** Burner Testing
- **Task 7:** 3-D Simulation of Staged-OMB Gasifier and Burner Effect
- **Task 8:** Technical and Economic Analysis

CWS Preparation



Ability to test different coals & CWS properties

- Gibson Coal
- River View Coal
- Powder River Basin Coal

- Additives
- Particle size
- Desired slurry characteristics

Typical Properties of CWS

Average particle size (μm)	Mass concentration	Viscosity (mPa·s)
<50	<60%	<250

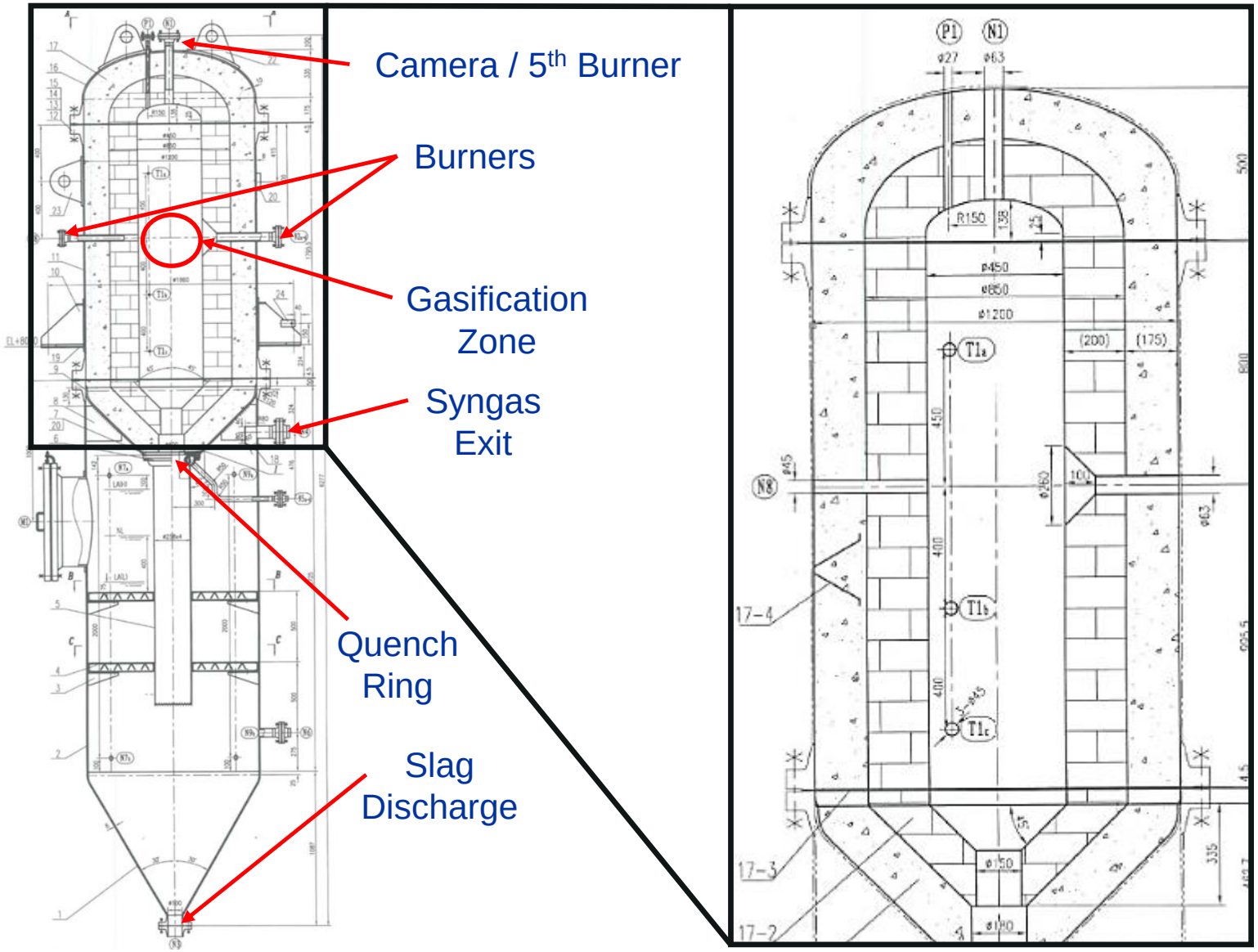
Opposed Multi-burner Gasification

Provides Flexibility for:

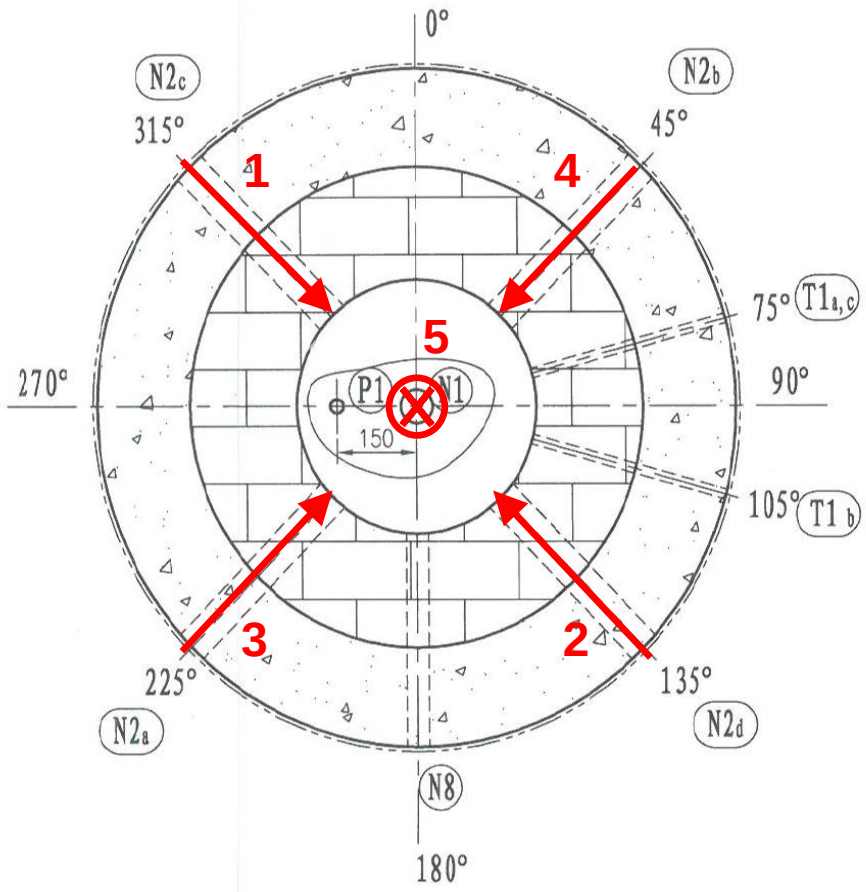
- Gasification
- Downstream Utilization

- Highly Load Flexible (20%-150%)
  - Slurry pumps scale capacity using frequency controller
  - Number of active burners can be increased or decreased
- Variety of Feedstocks
- Co-feed Capability (Coal and Natural Gas)

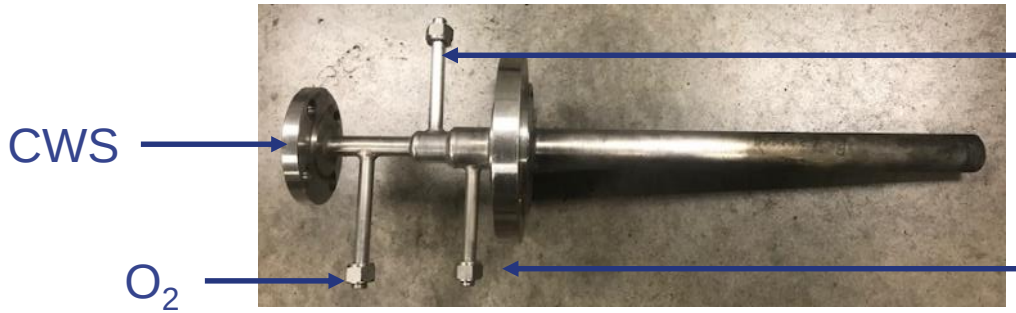
Staged Opposed Multi-burner Gasifier

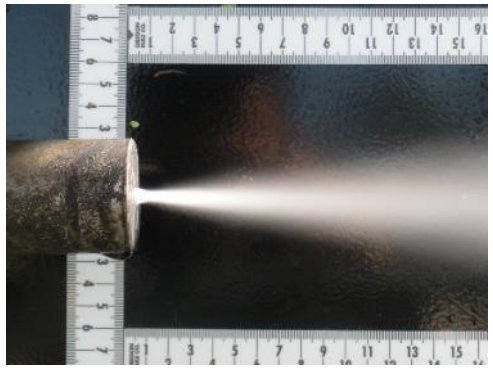


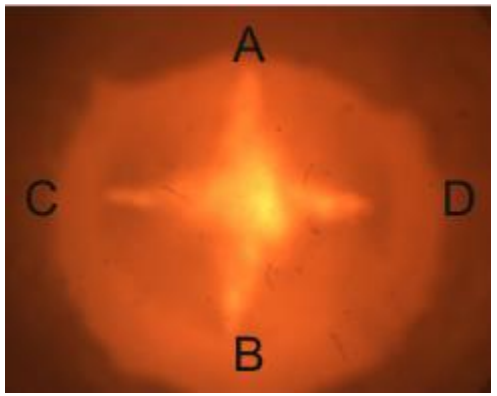
Top View



Burner Modification and Testing







Burner Test Stand

- Jig for burner installation
- Atomization testing
- Burner evaluation

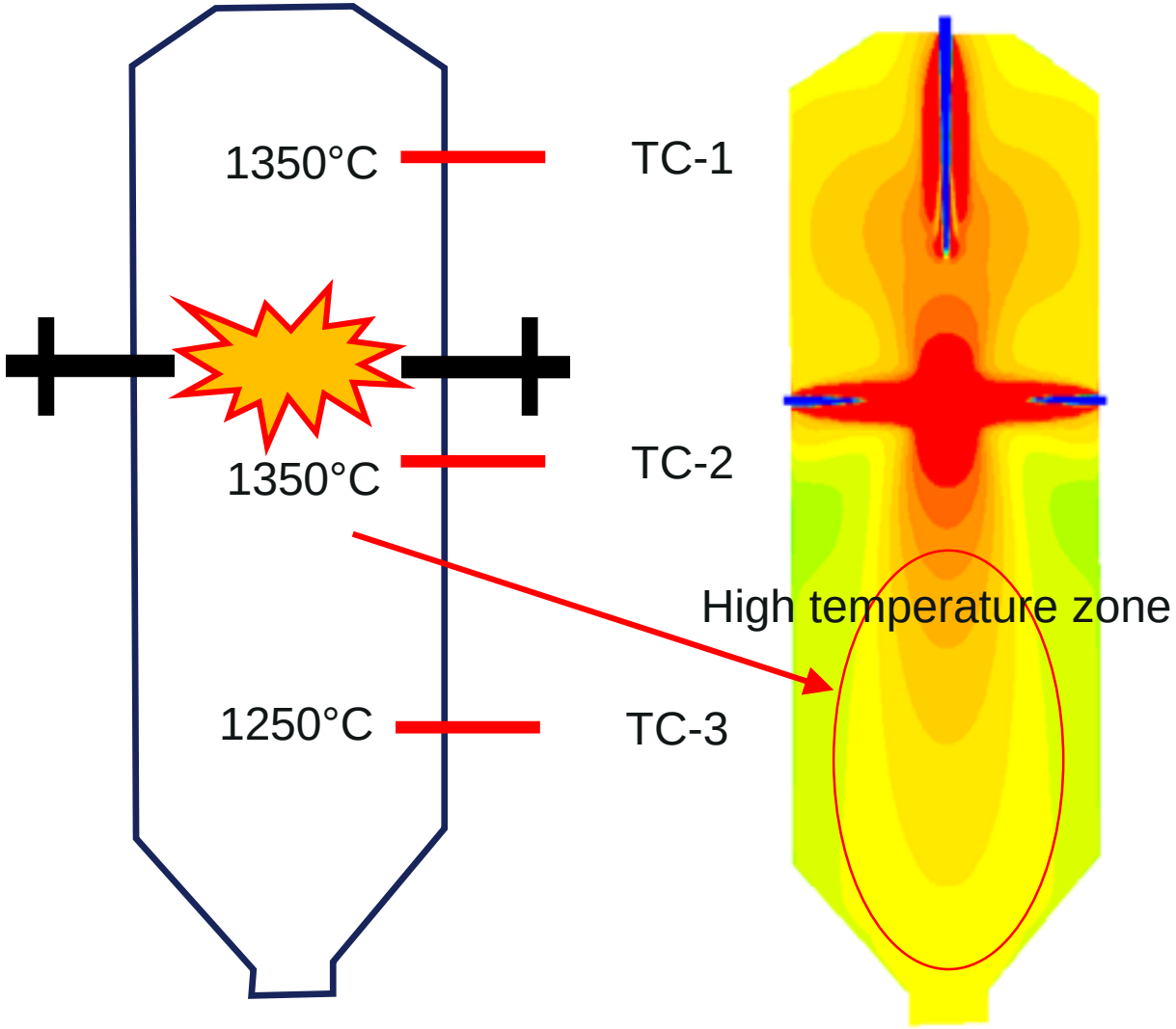
Commercial Velocity

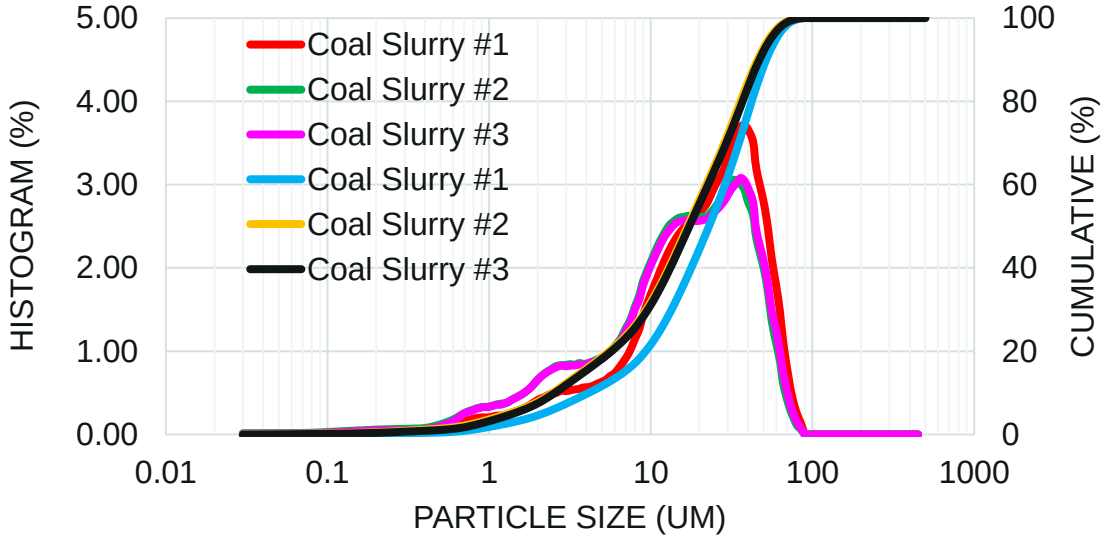
- 100-120 m/s

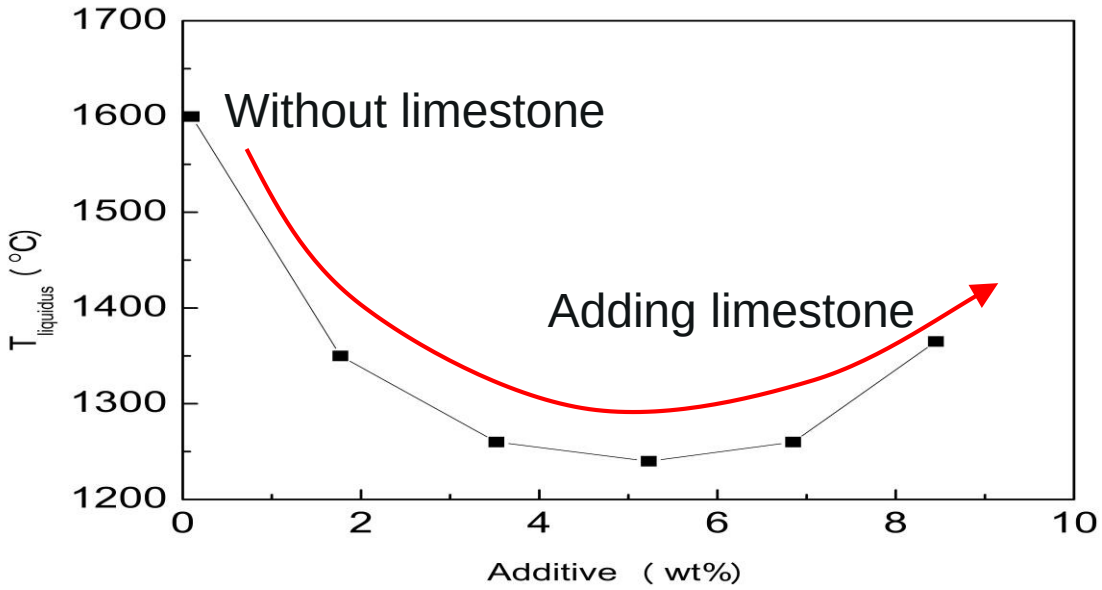
Project Updates/Accomplishments Summaries

- Project Results from 6 parametric campaigns:
  - CWS preparation and treatment
  - Gasification with CWS burners in service
  - Gasification with various CWS concentration
  - Gasification at different operating temperatures
  - Slag properties

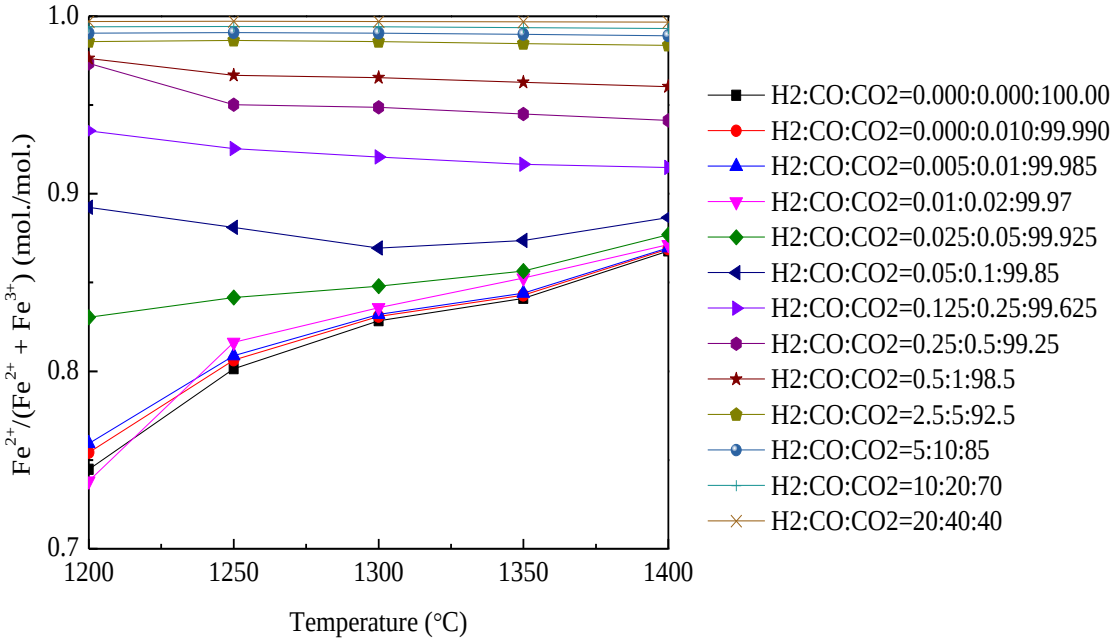
CWS Preparation and Treatment



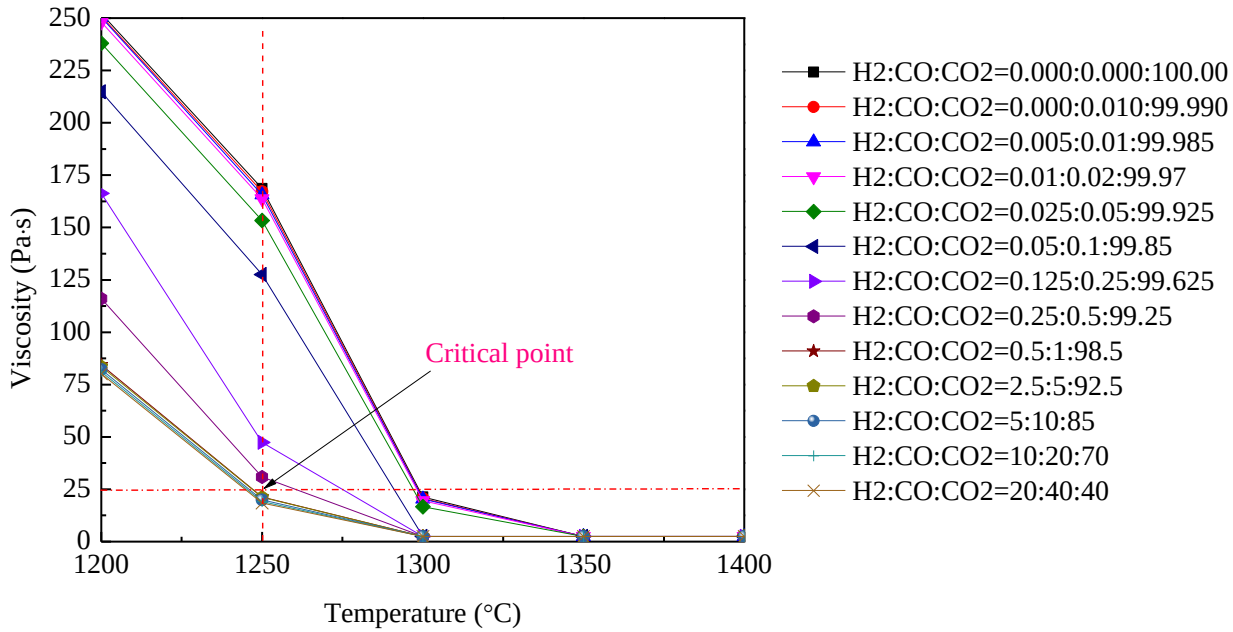




Gasifier Heating & Operating Critical Atmosphere Prediction

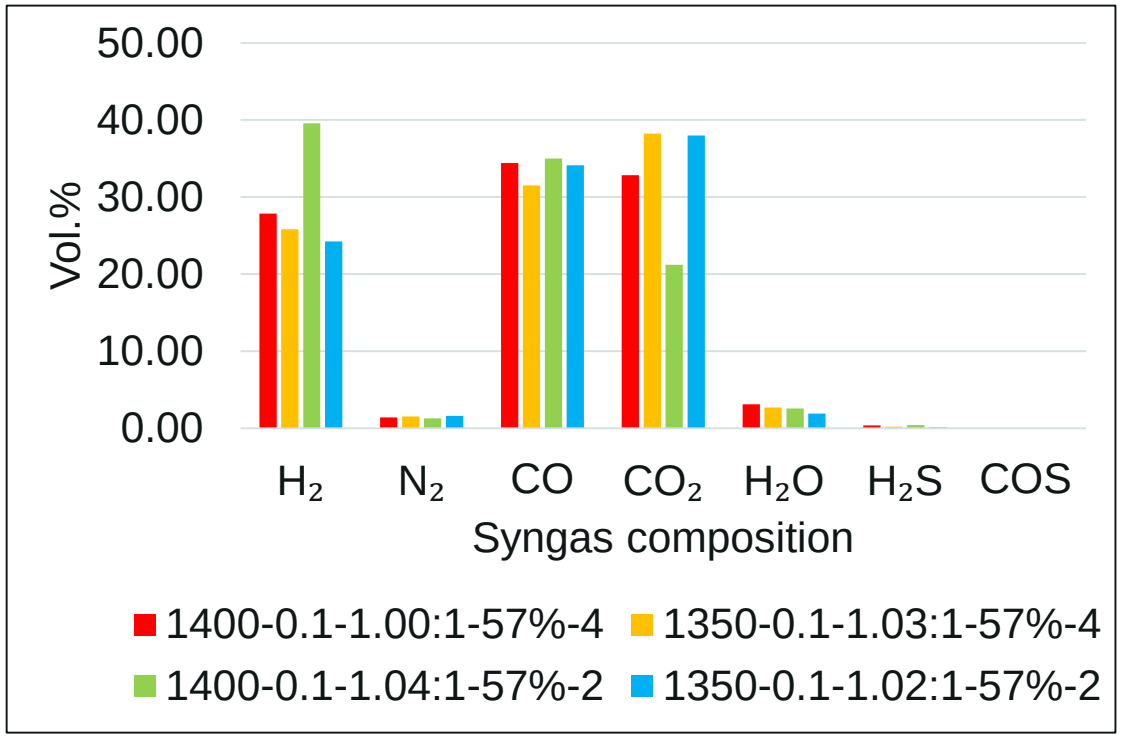


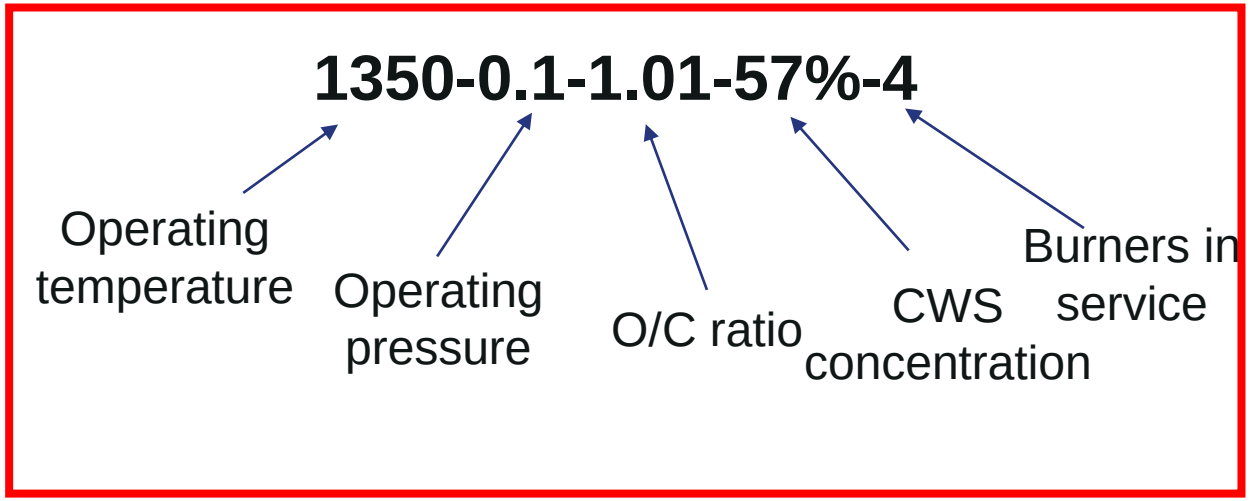
- With lower syngas content (H_2+CO), more Fe^{3+} is formed, especially when the temperature is below 1250 ℃
- The content of H_2+CO should be higher than 7.5 vol % so that there will be less Fe^{3+} in the slag.

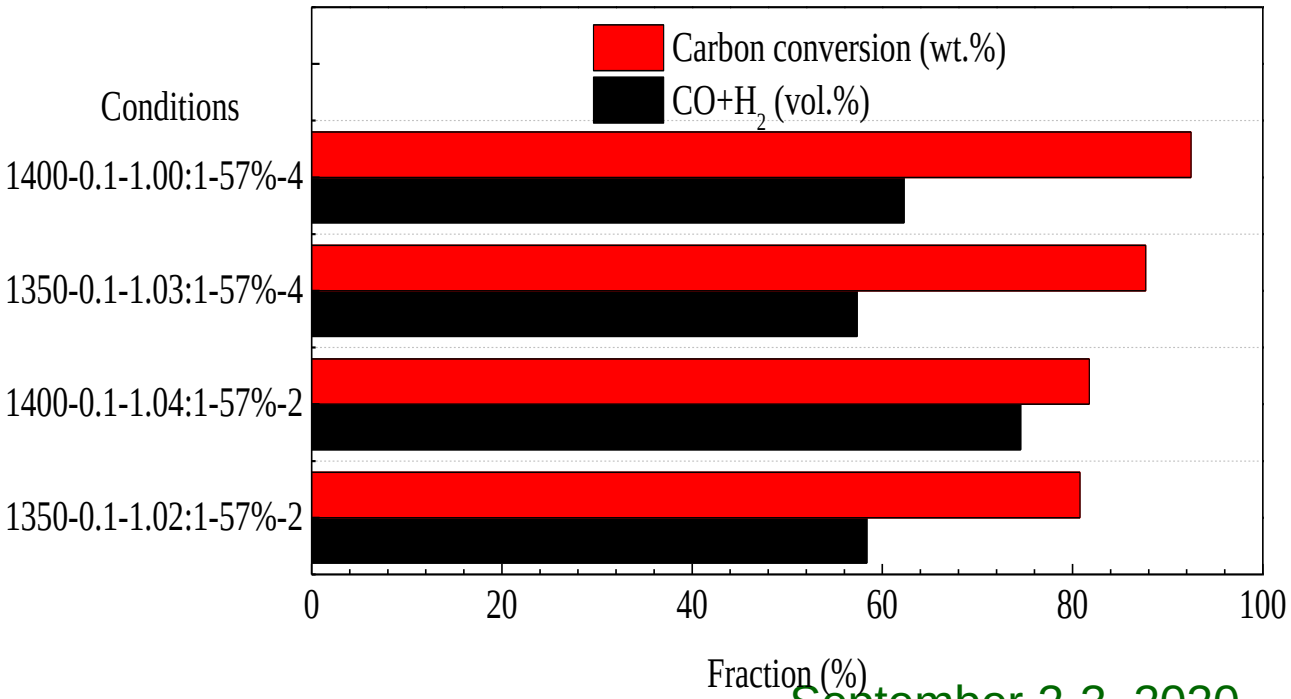


- Syngas content (H_2+CO) needs to be higher than 7.5 vol % and the viscosity of the slag at 1250 ℃ will be lower than 25 Pa s.

Gasification with Various Loading

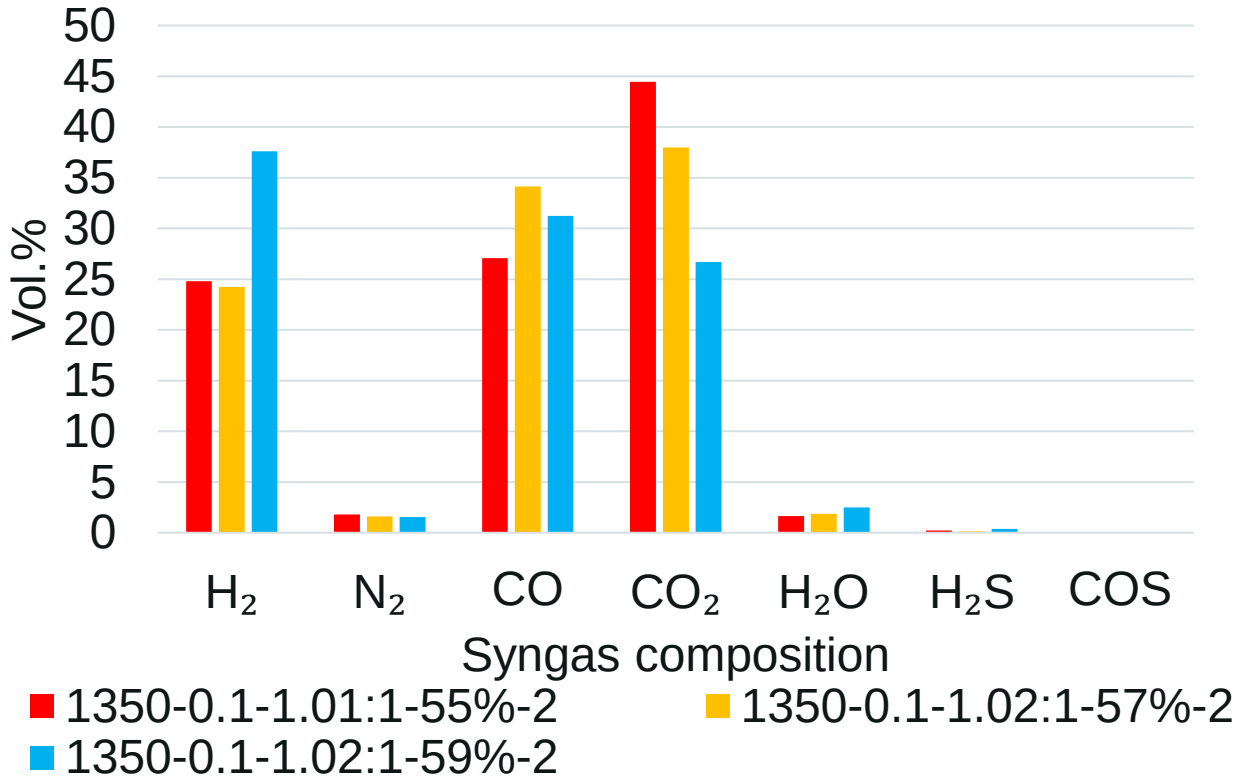


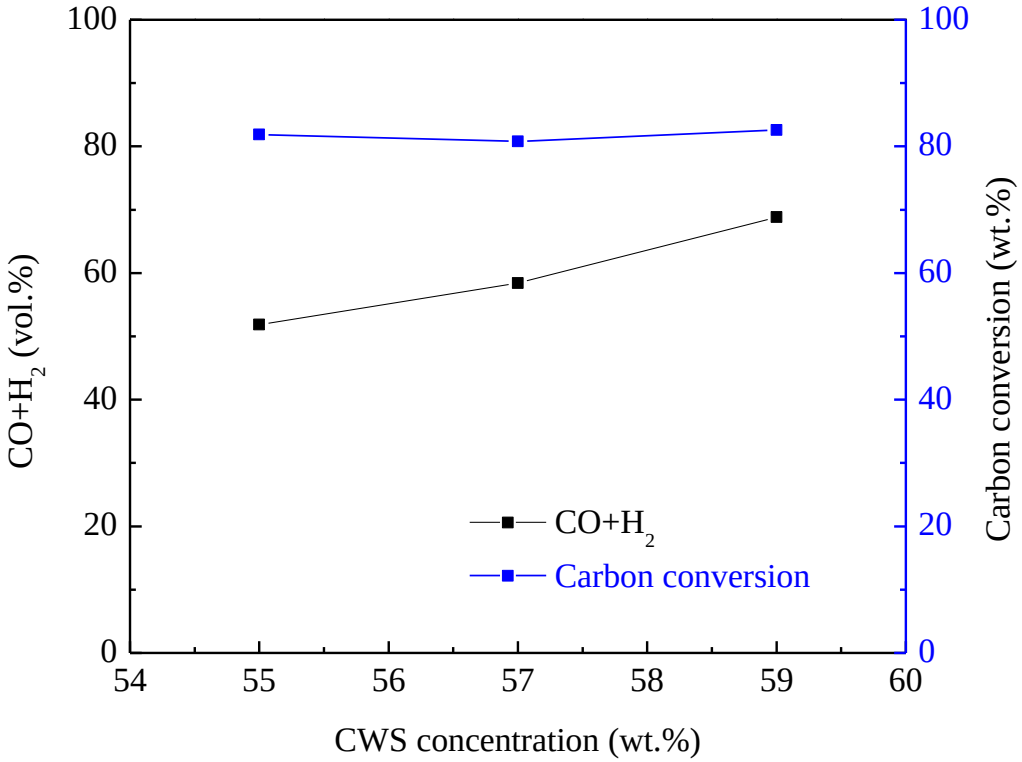




- Operation with 4 burners at 1400℃ achieves 62 vol.% effective syngas content ($CO+H_2$) with a high carbon conversion
- Operation with 2 burners needs combustion of NG to hold the temperature and the effective syngas is high due to the partial gasification of NG.

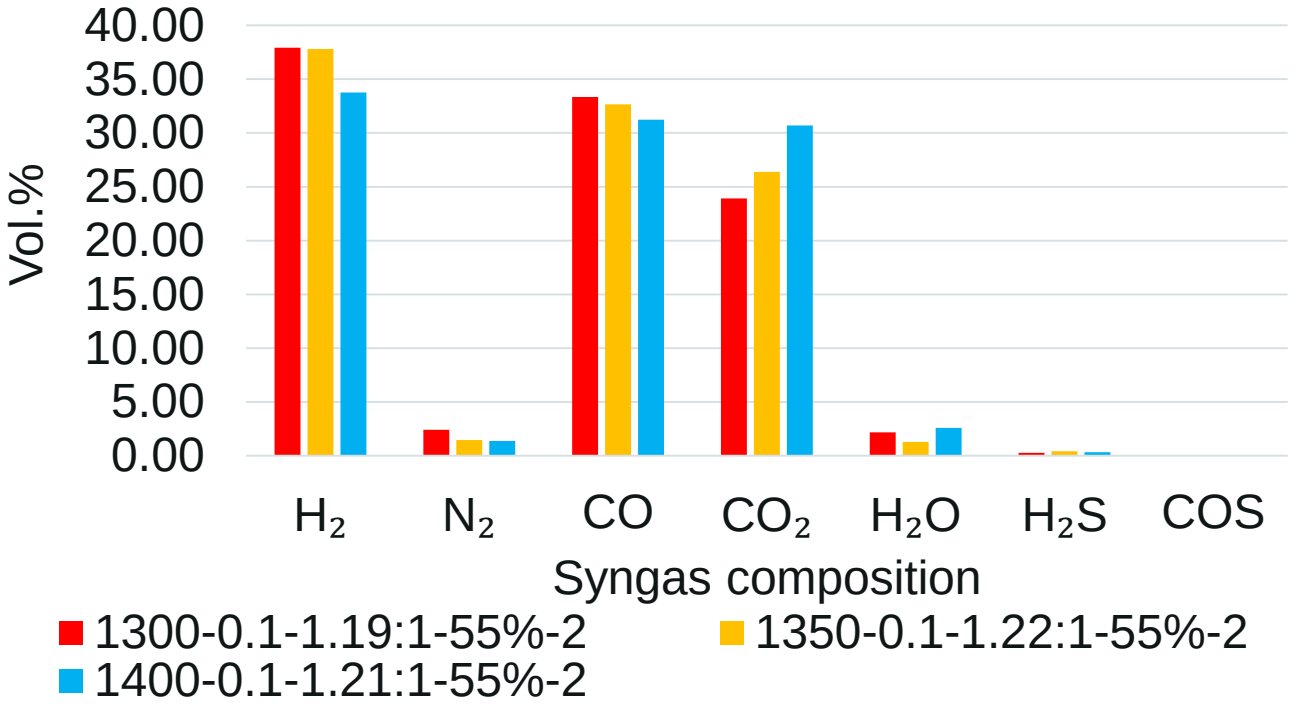
Gasification with Various CWS Concentrations

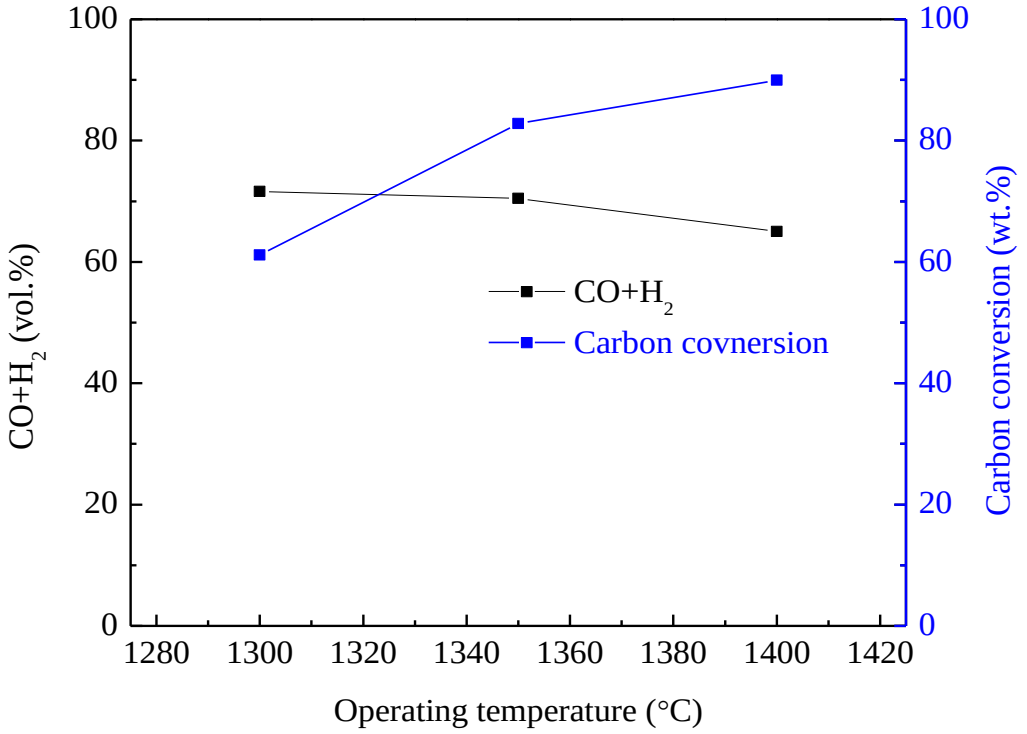




- The H_2 content at the condition increased with CWS concentration
- Both the effective syngas content and carbon conversion increased with the concentration of CWS.

Gasification at Different Operating Temperatures





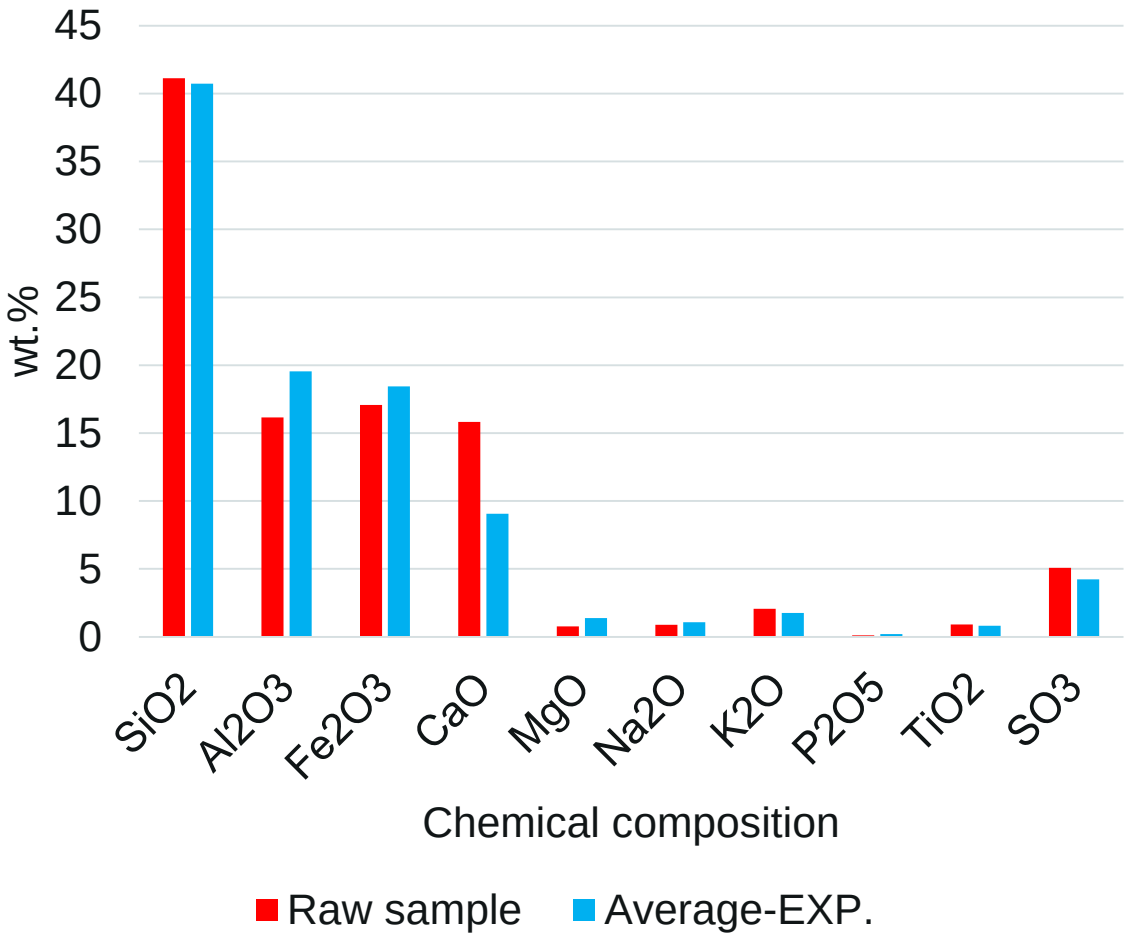
- The H_2 content decreased with the increasing operating temperature but are higher than the contents of CO and CO_2 for all three conditions.

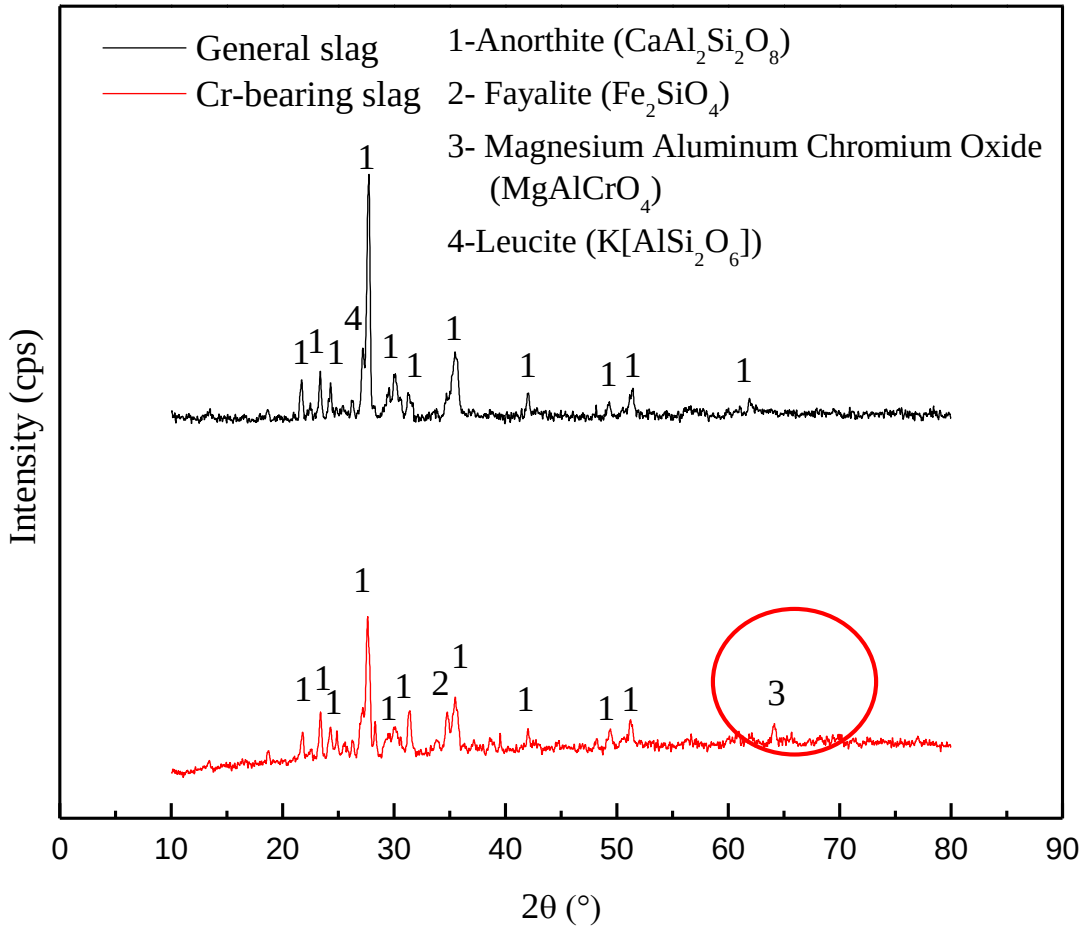
Mixture of Coal Ash, LW Castable, and Mortar during Gasification

Chemical Composition (wt.%)	RV	RV+1wt.% LM	LW CASTABLE	CrM	Castable Refractory
SiO_2	45.88	41.12	39.30	0.00	60.00
Al_2O_3	18.02	16.15	44.60	95.00	25.00
Fe_2O_3	19.04	17.07	1.30	0.00	0.00
CaO	6.07	15.81	11.80	0.00	0.00
MgO	0.85	0.77	0.40	0.00	0.00
Na_2O	1.00	0.89	0.35	0.00	0.00
K_2O	2.31	2.07	0.35	0.00	0.00
P_2O_5	0.13	0.12	0.00	0.00	0.00
TiO_2	1.02	0.91	1.90	0.00	0.00
SO_3	5.68	5.09	0.00	0.00	0.00
Cr_2O_3	0.00	0.00	0.00	5.00	0.00

RV: River view coal ash LW: lightweight castable LM: Limestone CrM: Chrome corundum mortar

Chemical Composition of Slags





- Collected slag sample from the gasifier shows lower Ca content compared to the mixed coal ash sample
- With mortar on the refractory, Cr would merge into the coal slag and change the mineral type in comparison with general slag

Conclusions

- Highly Load Flexible testing (50%-100%) of the Staged OMB gasification is completed while the rest of the testing for 25% and 125% is ongoing.
- Coal slurry ability is lifted with testing different additive and coal types.
- Coal ash fusibility are predicted via experimental and modeling method.
- Parametric testing of the Staged OMB gasification is ongoing and includes, but is not limited to:
  - CWS burners in service
  - CWS concentration
  - Operating temperatures
  - Slag discharge optimization
- Fuel flexibility texting

Acknowledgements

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