Cold flow analysis for a scaled bubbling fluidized bed gasifier: impact of various feedstocks and fluidizing materials

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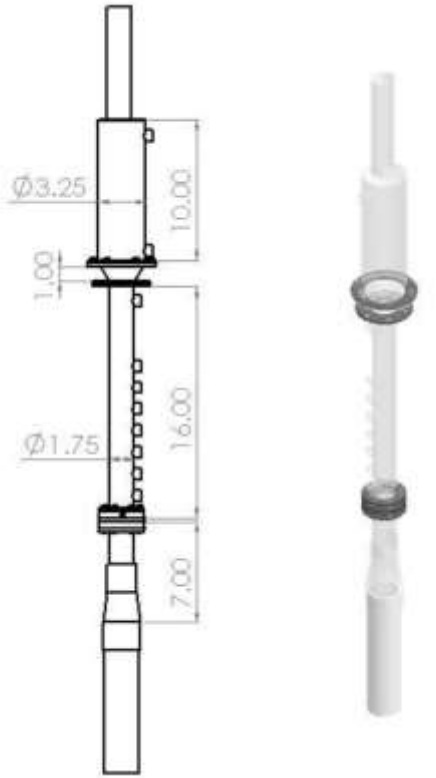
Objectives

- Cold flow analysis allows us to simulate the process and obtain the hydrodynamic properties of the reaction bed.
- Good-mixture and good-fluidization conditions have been observed (air volumetric flow rate, static bed height, fluidizing material type and feedstock)
- Premixed and not premixed cases have been compared.

Experimental Setup



Material Characteristics

Table 1. Material size and sphericity analysis

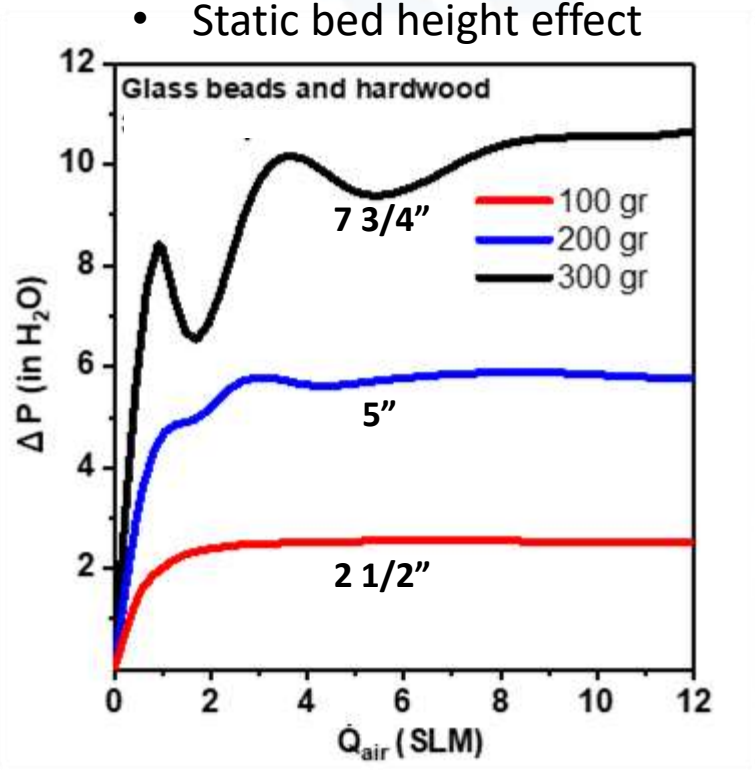
Material	Average of particle size (μm)	Average of Sphericity
Hardwood	432	0.564
Coal	310	0.761
Glass beads	279	0.933
Sand	368	0.863

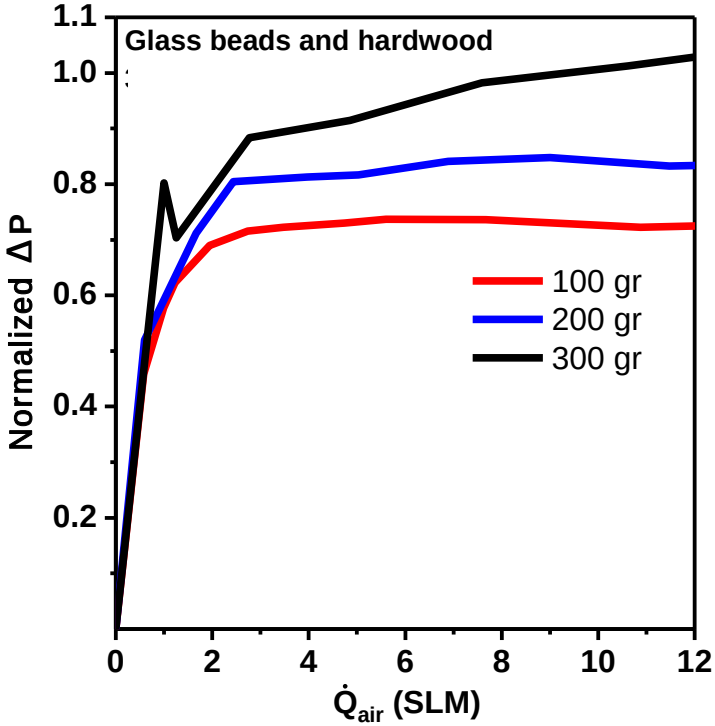
Table 2. Material bulk density and voidage analysis

Material (Mixtures)	Bulk density (g/cc)	Voidage (%)
Glass beads + coal	1.61	35
Glass beads + hardwood	1.43	38
Sand + coal	1.56	41
Sand + hardwood	1.38	44

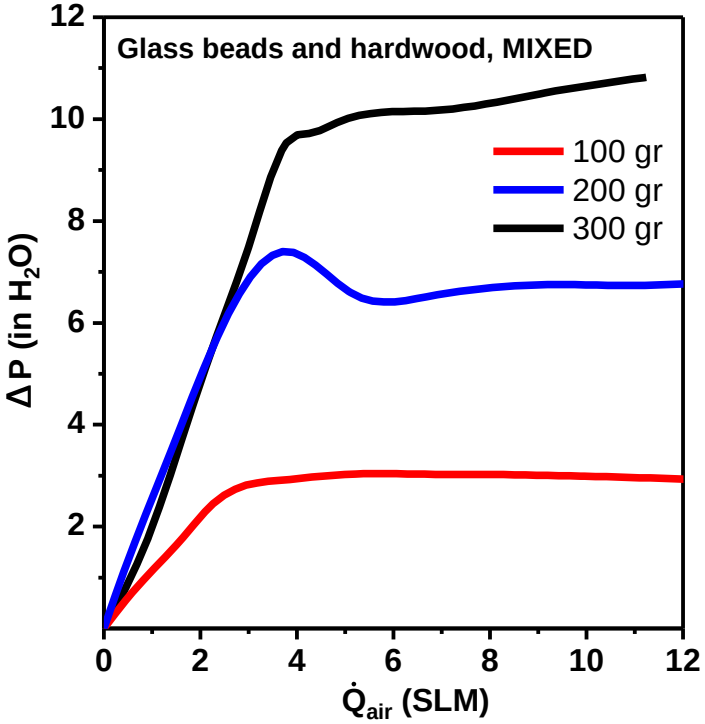
Pressure drop versus air volumetric flow rate diagrams

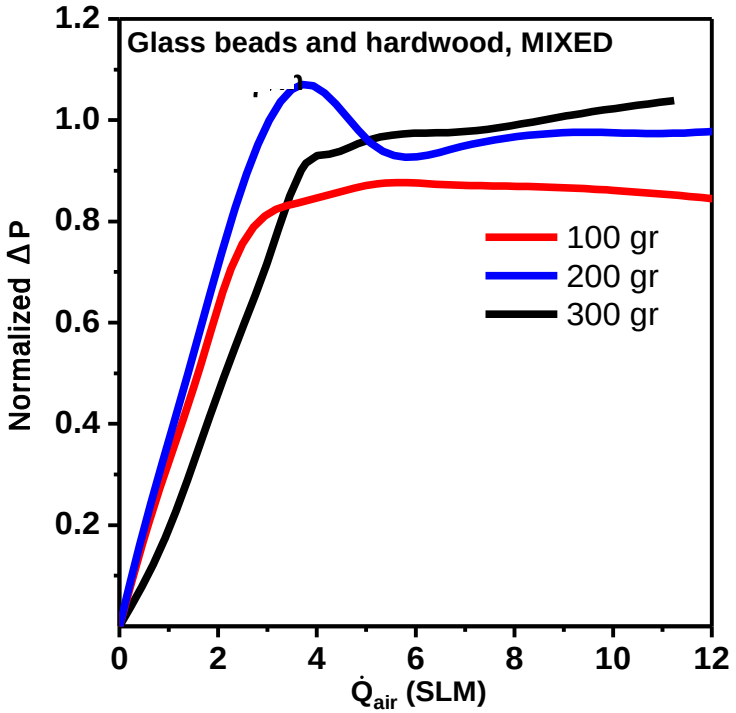
- Static bed height effect



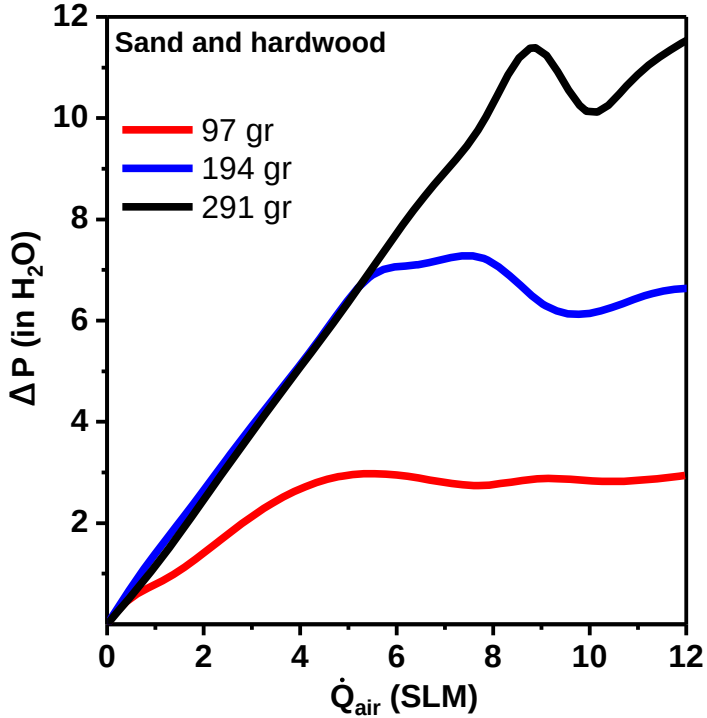


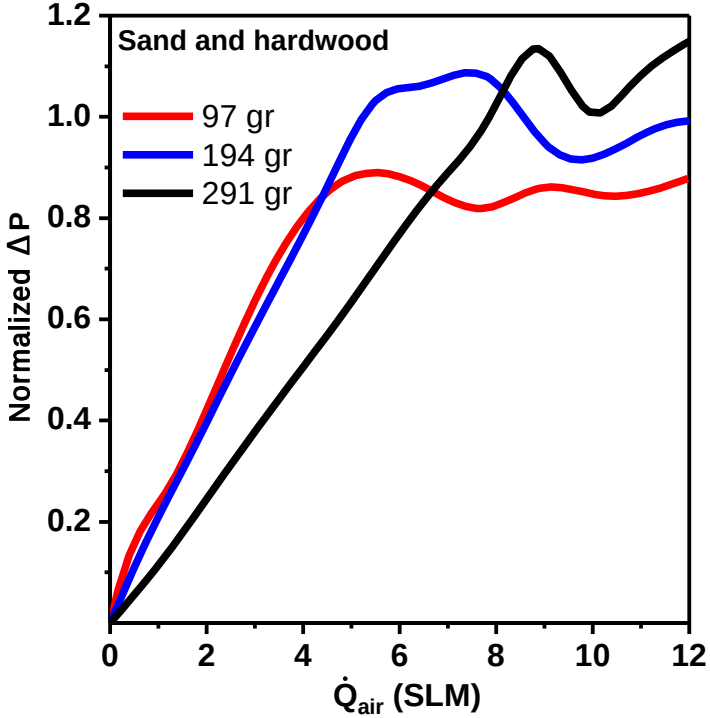
- In the premixed case better fluidization obtained

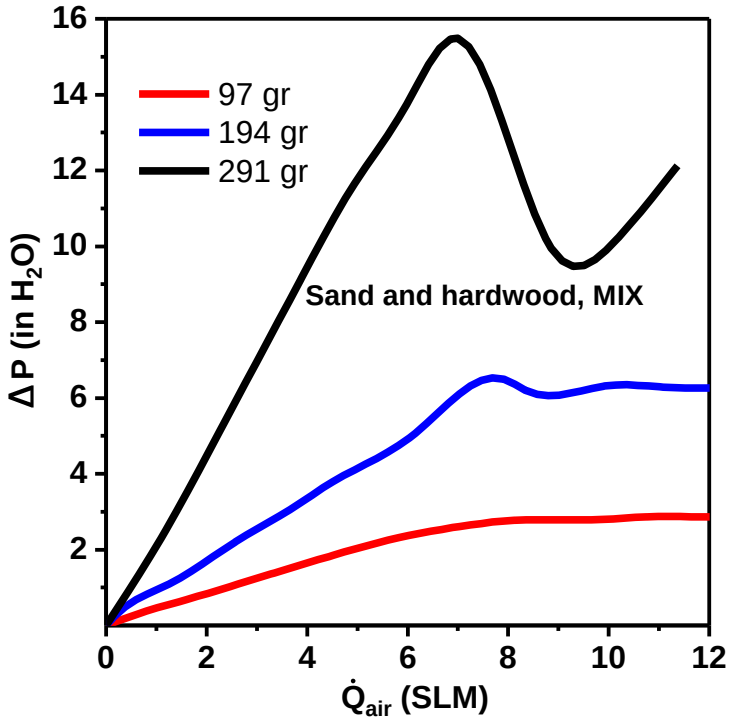


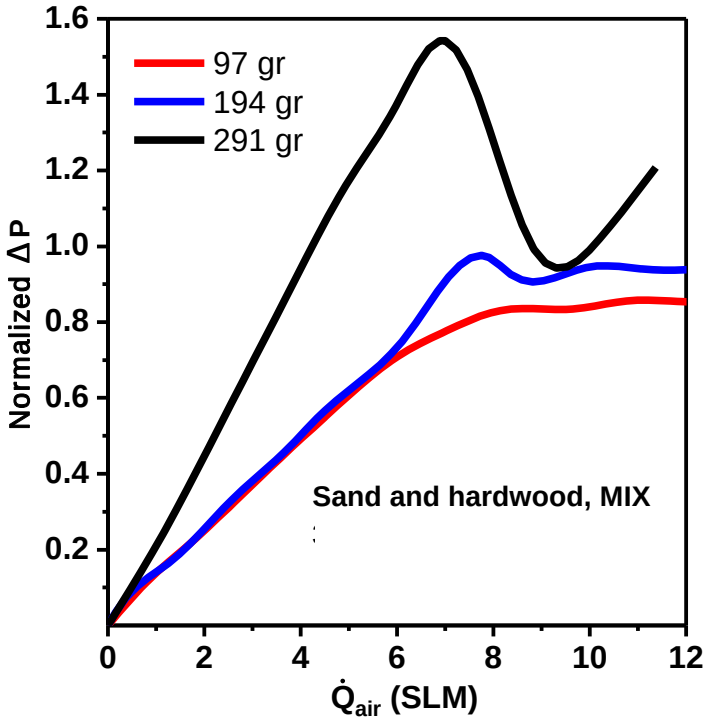


- Bulk density and voidage effect

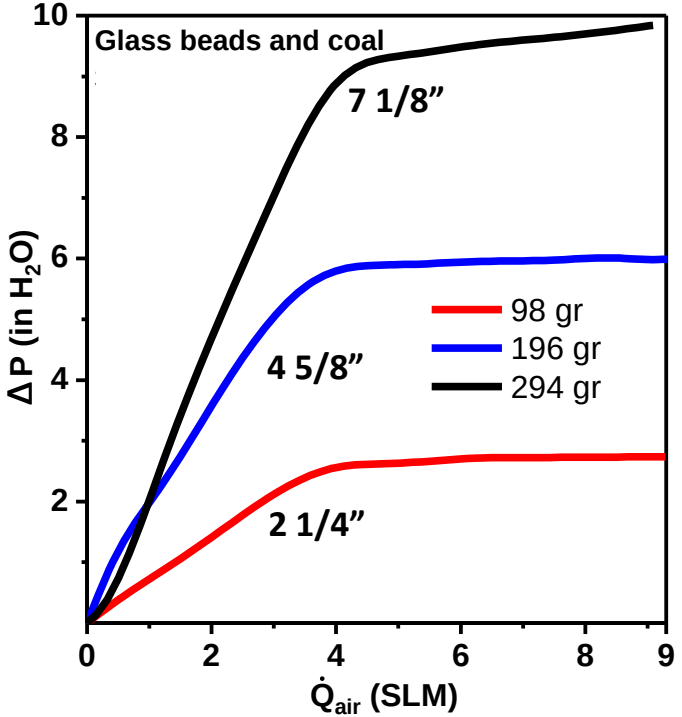


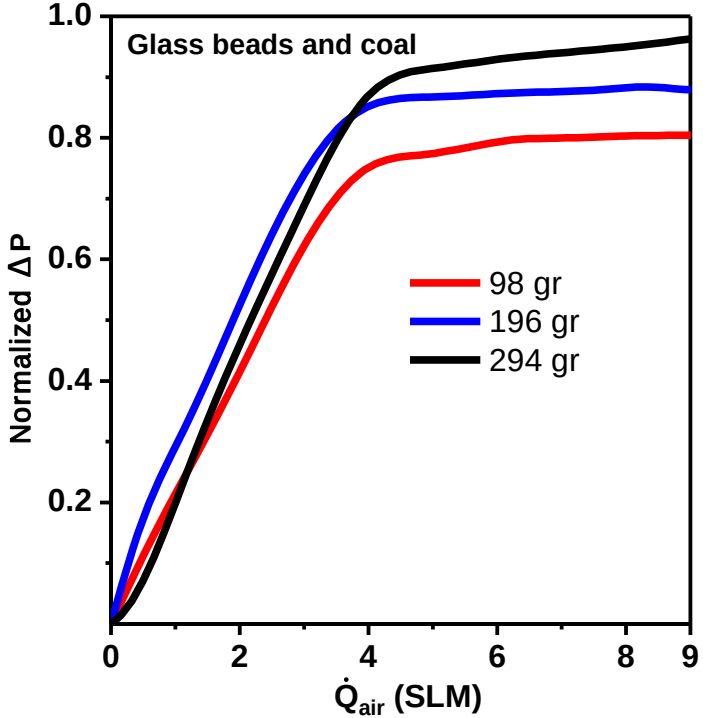


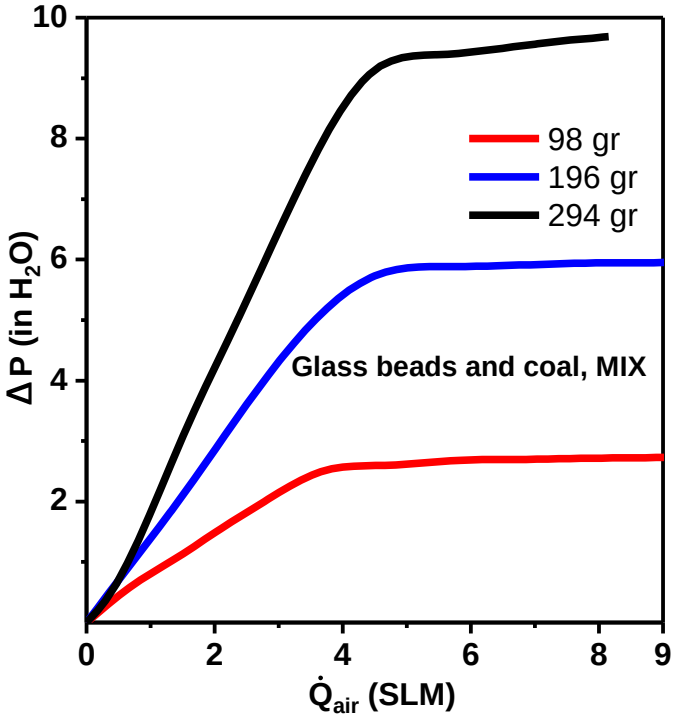

16
14
12
10
8
6
4
2
ΔP (in H2O)
97 gr
194 gr
291 gr
Sand and hardwood, MIX
0
2
4
6
8
10
12
Q̇air (SLM)

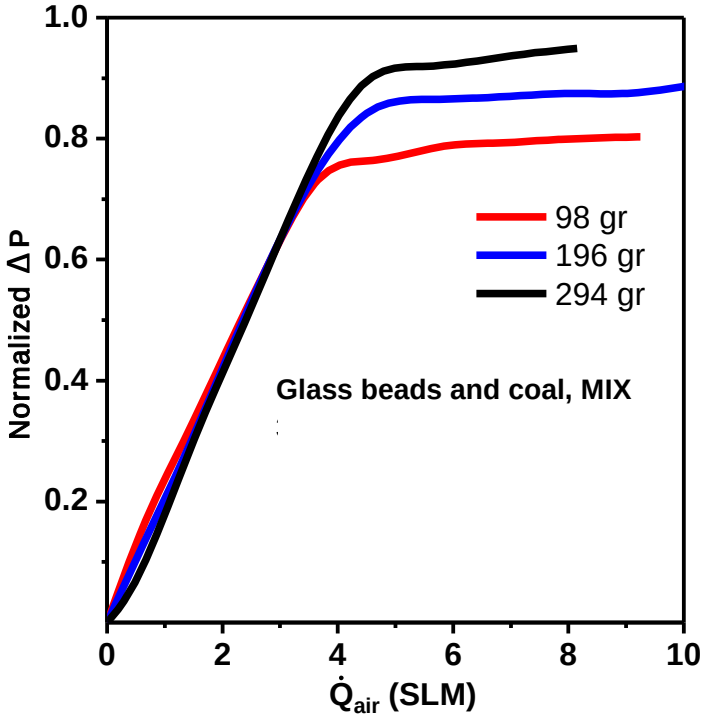

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Normalized ΔP
97 gr
194 gr
291 gr
Sand and hardwood, MIX
0
2
4
6
8
10
12
Q̇air (SLM)

- Coal and glass beads mixture has the highest bulk density and the lowest voidage ratio






10
8
6
4
2
ΔP (in H2O)
0
2
4
6
8
9
Q̇air (SLM)
98 gr
196 gr
294 gr
Glass beads and coal, MIX


1.0
0.8
0.6
0.4
0.2
Normalized ΔP
0
2
4
6
8
10
Q̇air (SLM)
98 gr
196 gr
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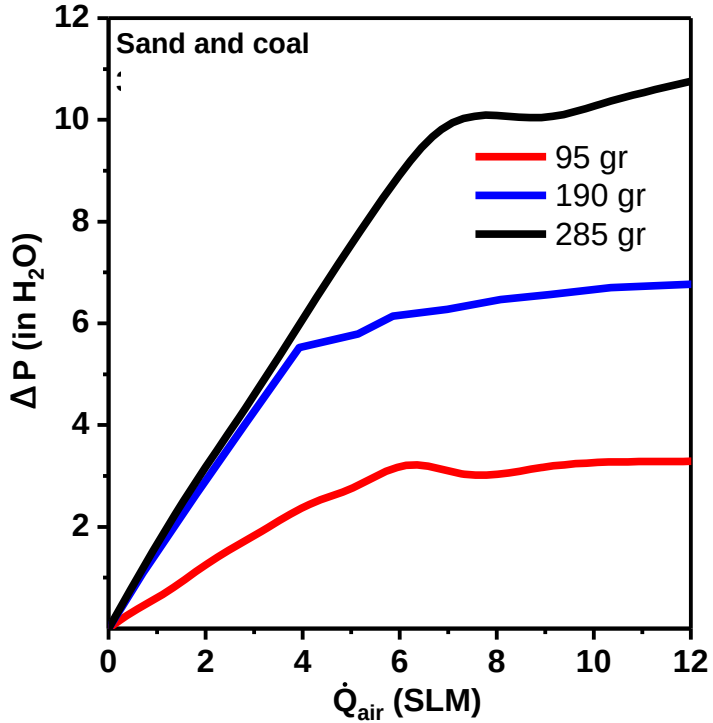
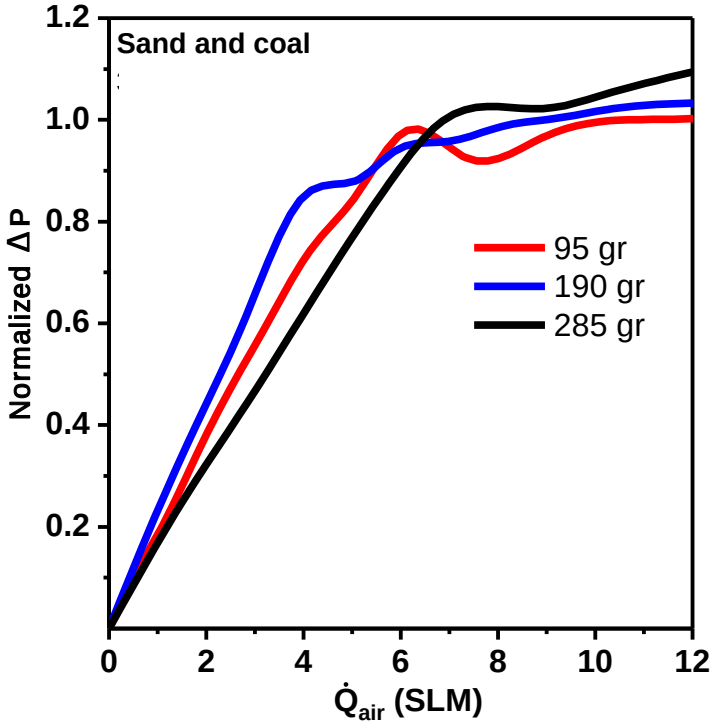
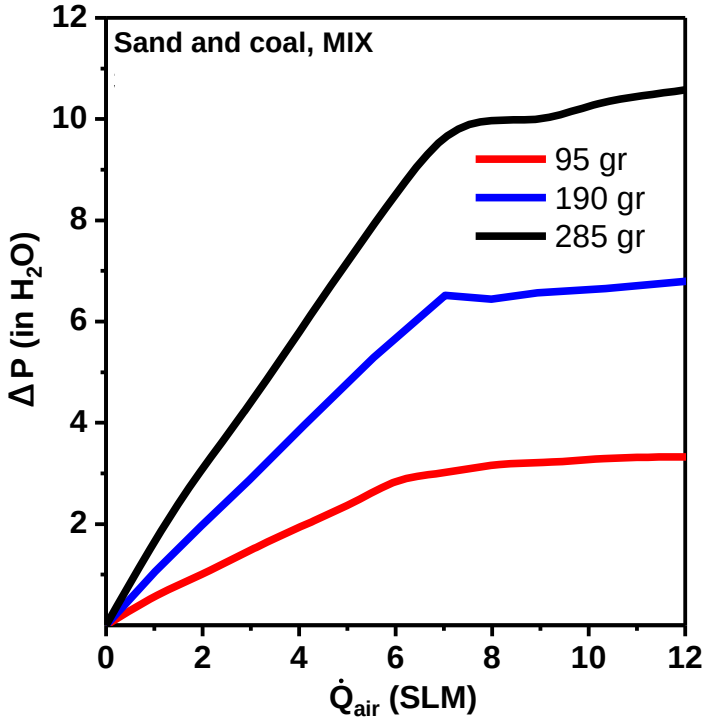
Glass beads and coal, MIX


Sand and coal
95 gr
190 gr
285 gr
ΔP (in H2O)
Q̇air (SLM)
12
10
8
6
4
2
0
2
4
6
8
10
12


Sand and coal
95 gr
190 gr
285 gr
Normalized ΔP
Q̇air (SLM)
1.2
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12


Sand and coal, MIX
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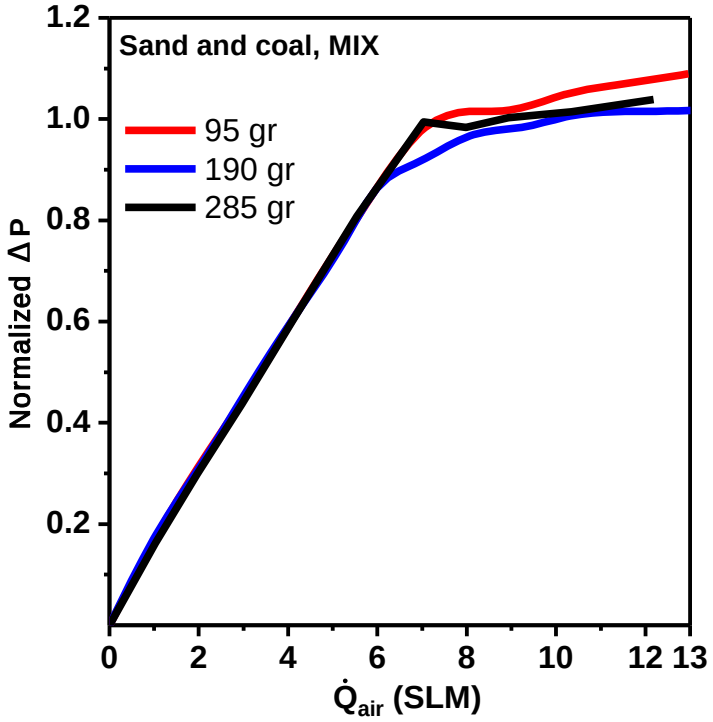
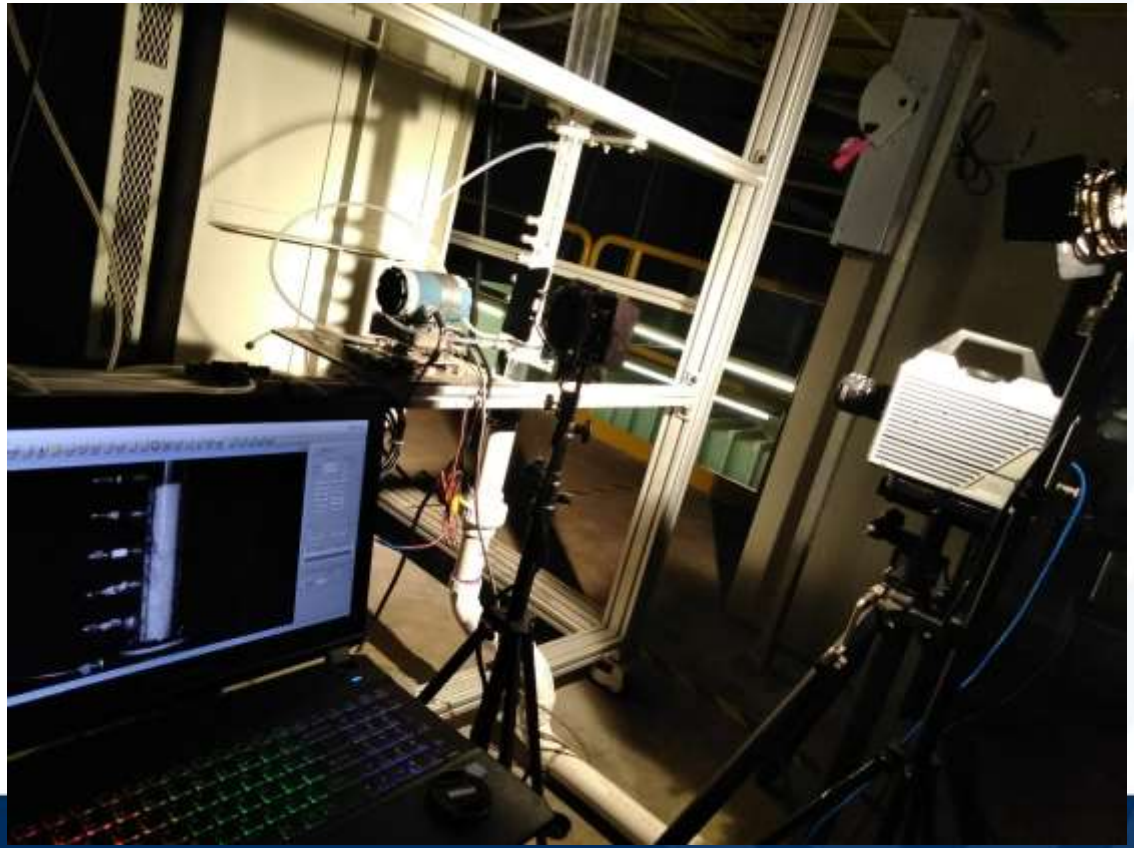
190 gr
285 gr
ΔP (in H2O)
Q̇air (SLM)
0
2
4
6
8
10
12


Sand and coal, MIX
95 gr
190 gr
285 gr
Normalized ΔP
Q̇air (SLM)
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
10
12
13

High speed imaging

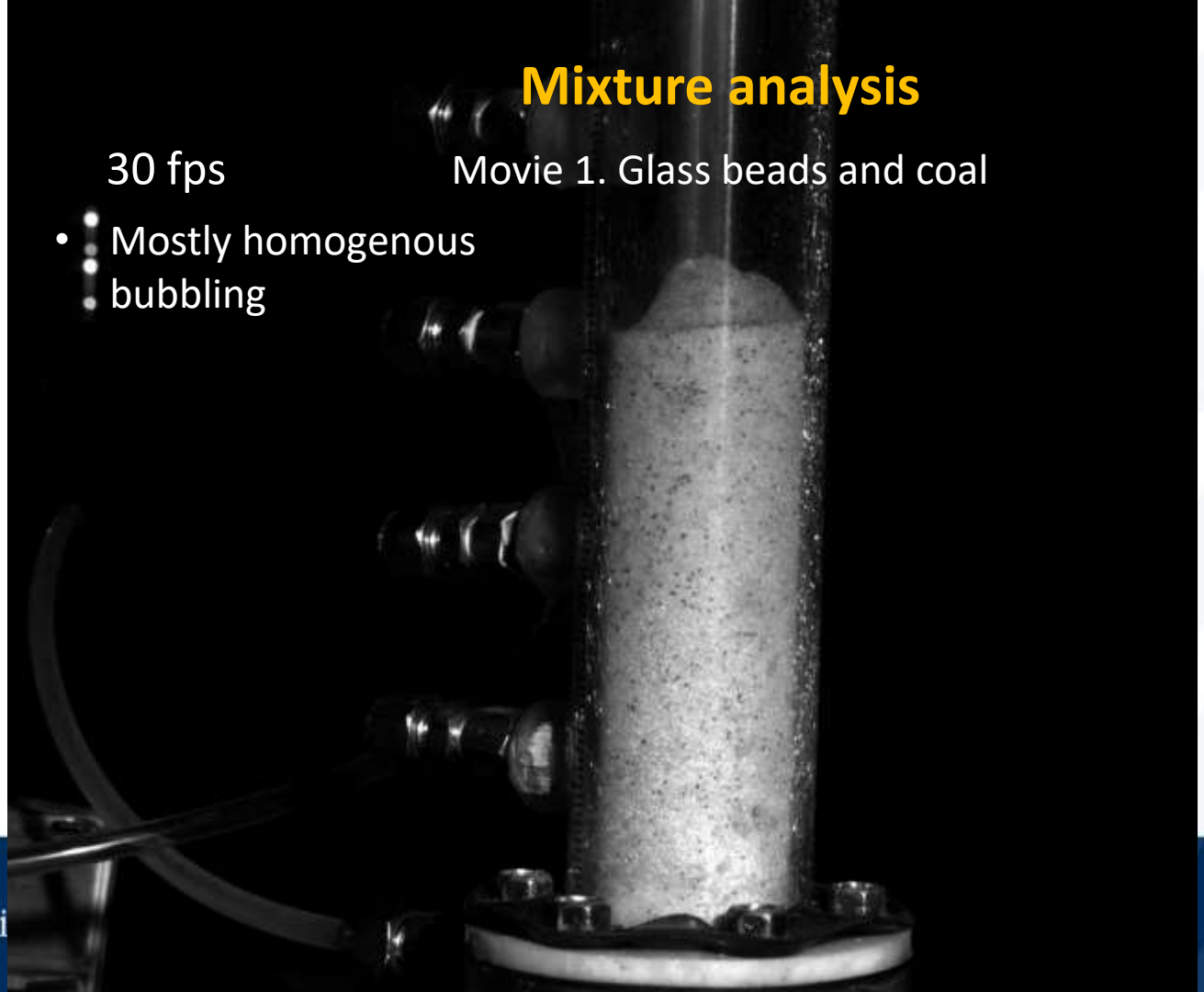


Mixture analysis

30 fps

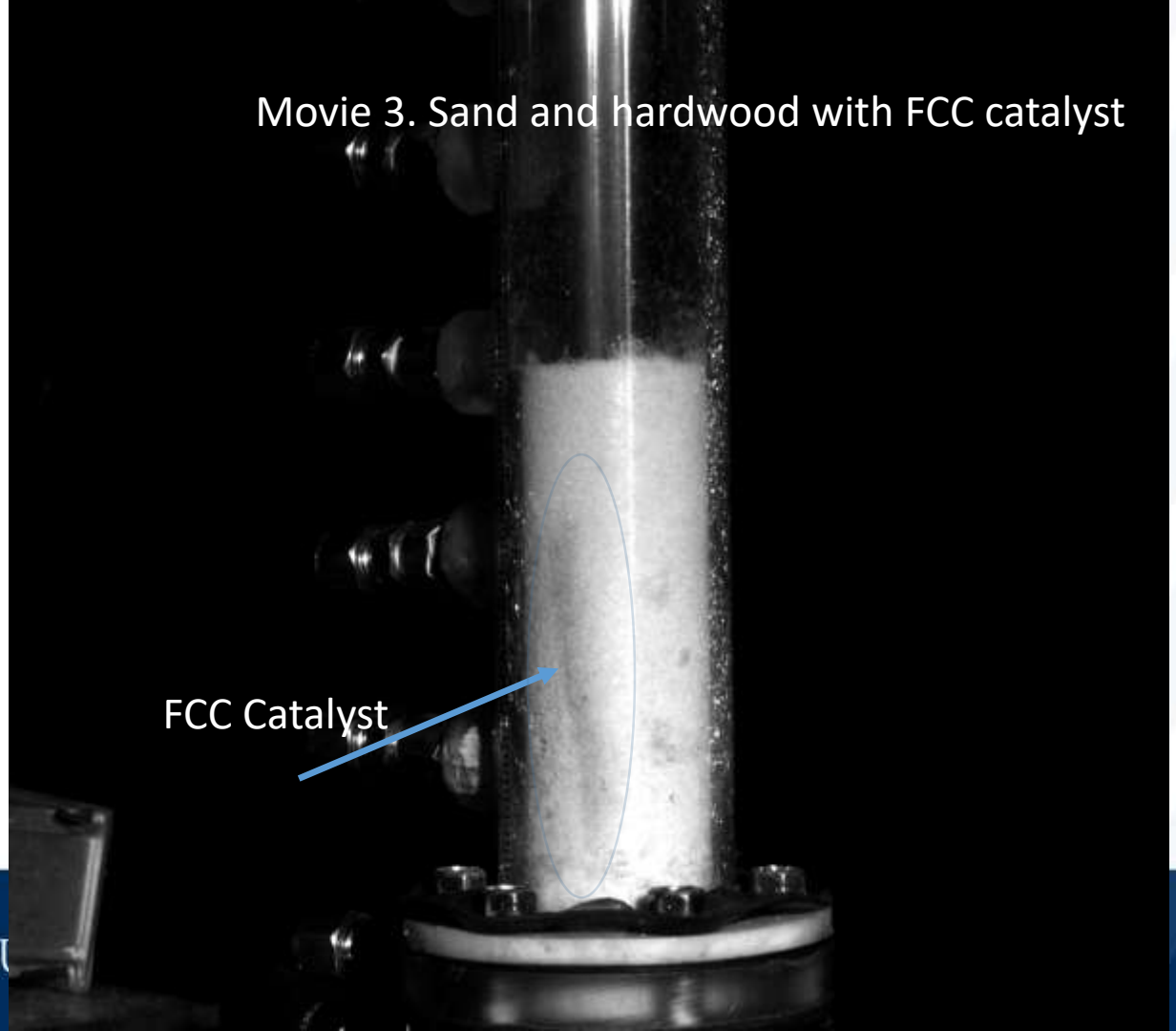
Movie 1. Glass beads and coal

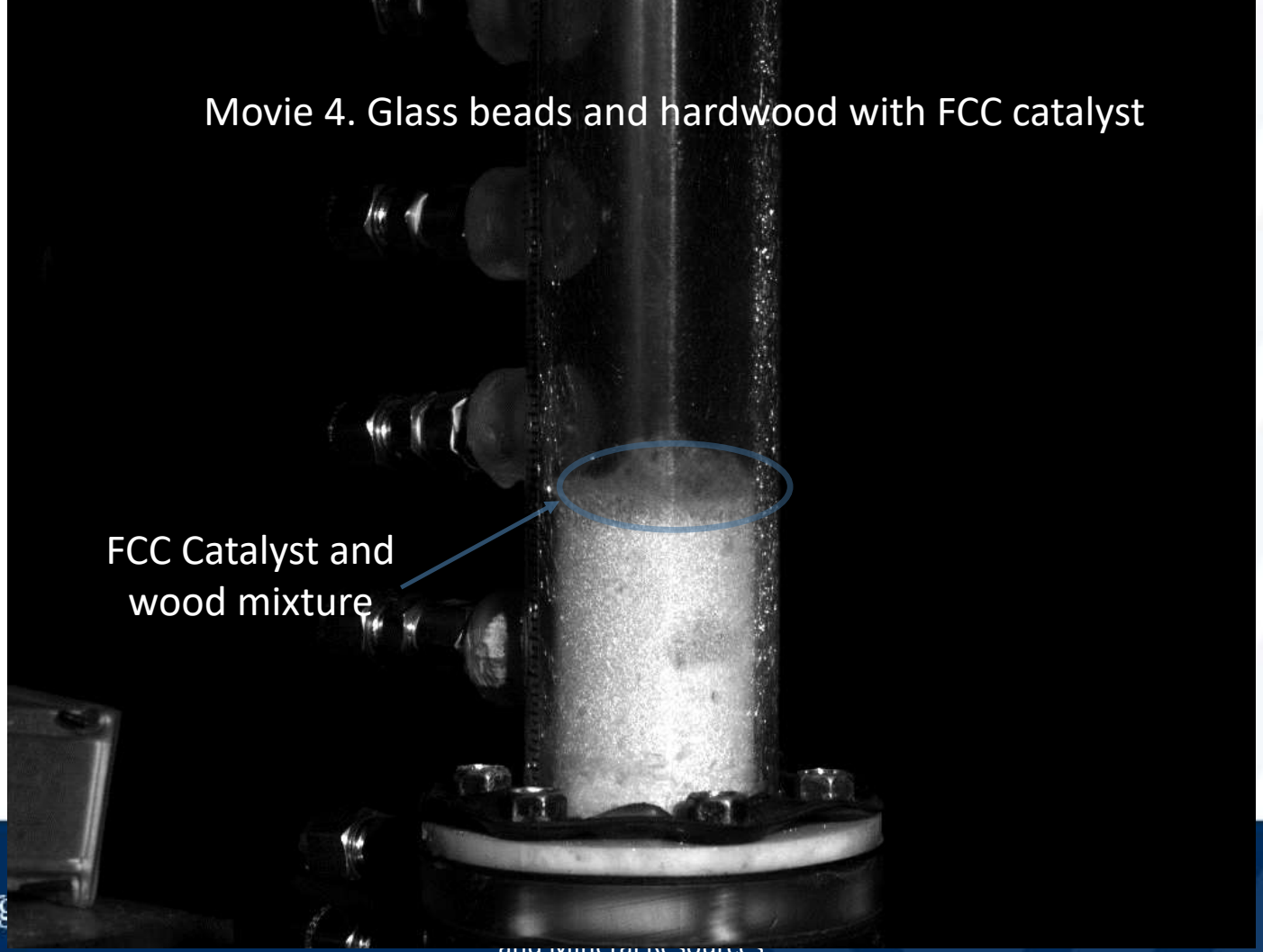
- Mostly homogenous bubbling




Movie 2. Sand and coal

Movie 3. Sand and hardwood with FCC catalyst




Movie 4. Glass beads and hardwood with FCC catalyst
FCC Catalyst and
wood mixture

Summary and Conclusions

- Better fluidization obtained for glass beads and coal because of its higher bulk density and lower voidage ratio.
- Good-mixture case for hardwood and fluidizing material mixture obtained between 2-2.5 times of minimum fluidization velocity.
- FCC catalyst acted like a bottom ash for sand and hardwood mixture.
- In addition to this study, studies of parametric reaction kinetics of biomass, coal, catalytic and non-catalytic gasification based on thermogravimetric analysis (TGA) and fixed bed reactor have been done by our group to develop optimized reaction operating conditions for fluidized bed gasifier.

Acknowledgements

Special thanks to *Department of Energy and National Energy Technology Laboratory*, *Morgantown Centre* for their technical and financial support.

Thank You

Questions