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The Effect of Air Separations on Fast Pyrolysis Products for Forest Residue Feedstocks

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Motivation

Biomass fractionation aims to separate biomass into distinct fractions based on their physical and chemical properties, such as particle size, density, and composition. By tailoring the composition and properties of biomass feedstock through fractionation, it will become possible to enhance the production of desired bio-oil via fast pyrolysis. Therefore, efficient fractionation techniques are essential to control these material attributes and optimize the fast pyrolysis process.

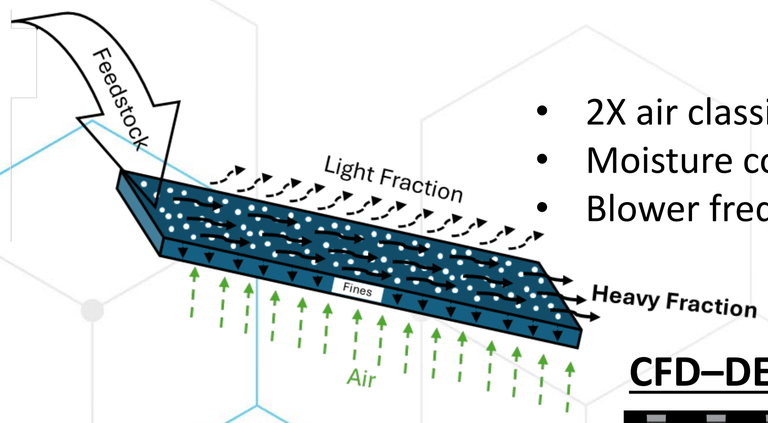
Objectives

The overall objective was to investigate the intricate relationship between biomass preprocessing and pyrolysis product yields.

- Effect of moisture content and air speed on fractionation.
- Employ a numerical simulation to predict the quality of the fractionated material.
- Apply computational fluid dynamics (CFD) and discrete element method (DEM) simulation model to forecast the pyrolysis product yields.

Methodology

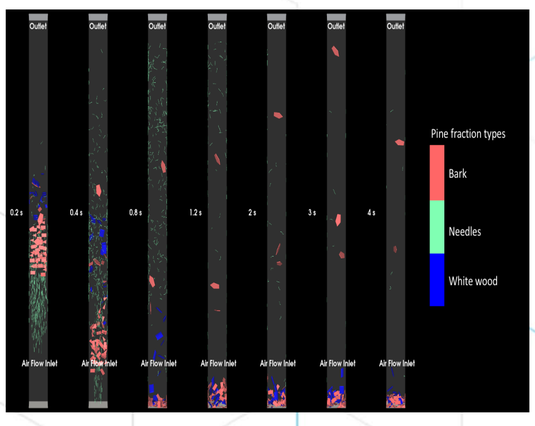
Air Classification (AC)



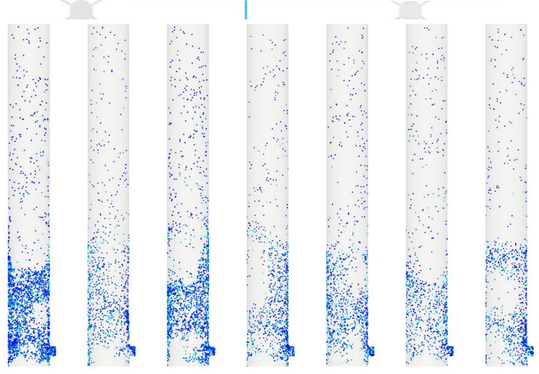
- 2X air classifier
- Moisture content: 10, 30, 55%
- Blower frequency: 10-30 Hz

CFD–DEM Simulation of AC

- Rocky DEM: Particle-particle interactions, and particle-wall
- Fluent CFD: Air flow

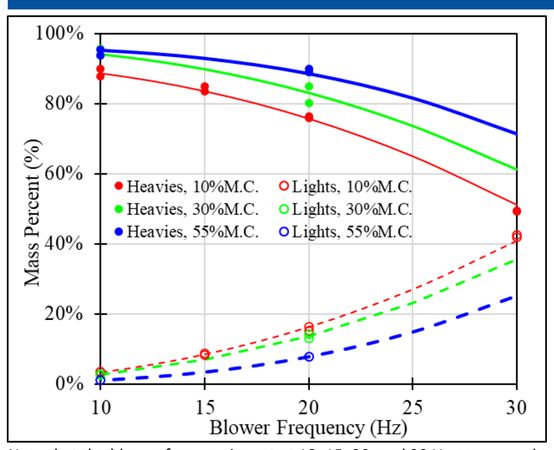


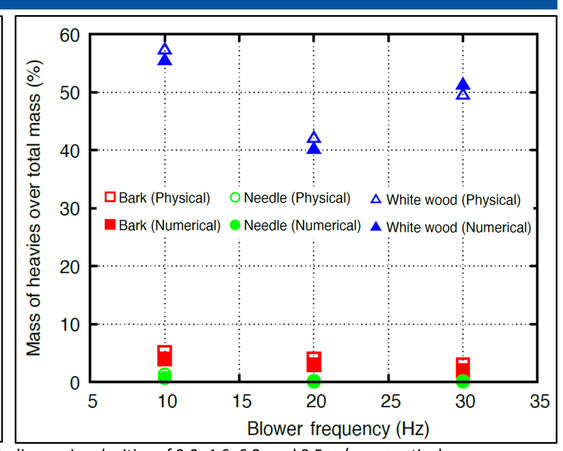
Pyrolysis Simulation



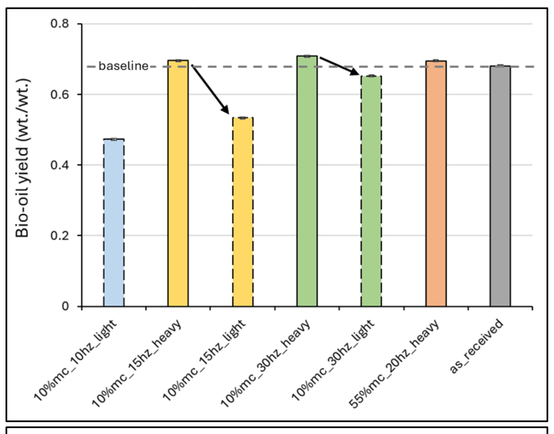
- A coarse-grained CFD–DEM framework was used
- Navier-Stokes equations for gas-phase transport behavior
- Newton's laws of motion to track particle-phase flows

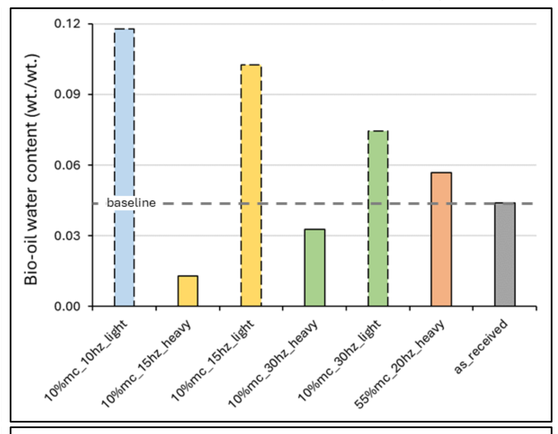
Results

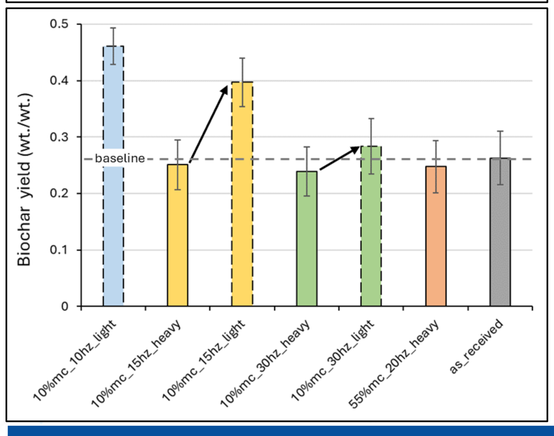


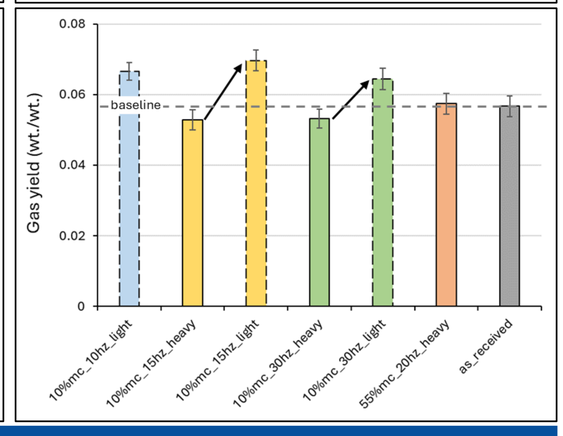


Note that the blower frequencies set at 10, 15, 20, and 30 Hz correspond to linear air velocities of 3.0, 4.6, 6.3, and 9.5 m/s, respectively.





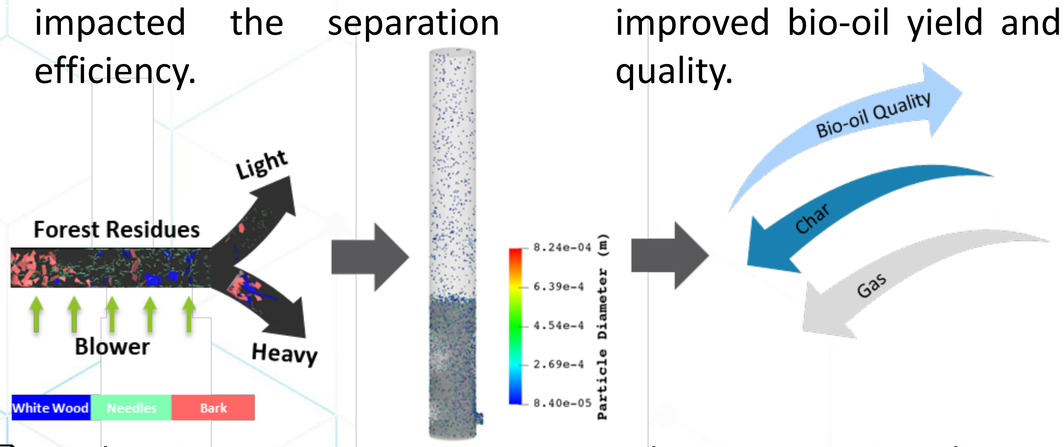




Conclusions and Recommendations

✓ Moisture content negatively impacted the separation efficiency.

✓ Mild air classification improved bio-oil yield and quality.



❑ Further investigations are warranted, encompassing diverse biomass types, and inorganic impacts to refine predictions of the overall process.

Acknowledgements

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Reference: N. Saha, J. Klinger, T. Bhattacharjee, Y. Xia, V. Thompson, O. A. Oyedeji, J. Parks, M. Shahnam, and Y. Xu, "The effect of air separations on fast pyrolysis products for forest residue feedstocks," *Fuel*, 2024. https://doi.org/10.1016/j.fuel.2024.132572