



# Variable Orientation of Biomass/Fast Microwave Pyrolysis Yield

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*Changing the World's Energy Future*

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<sup>1</sup>INL- Biomass Characterization

## My Inspiration:

Being able to create fuel from a renewable material is a crucial practice that could be pivotal in our future for energy. However, the methods to create and study these fuels can be unreliable due to user error, biomass composition, heating rates, etc.. This data is meant to possibly utilize a more efficient method of collecting data as well as fuel that eliminates some human error.

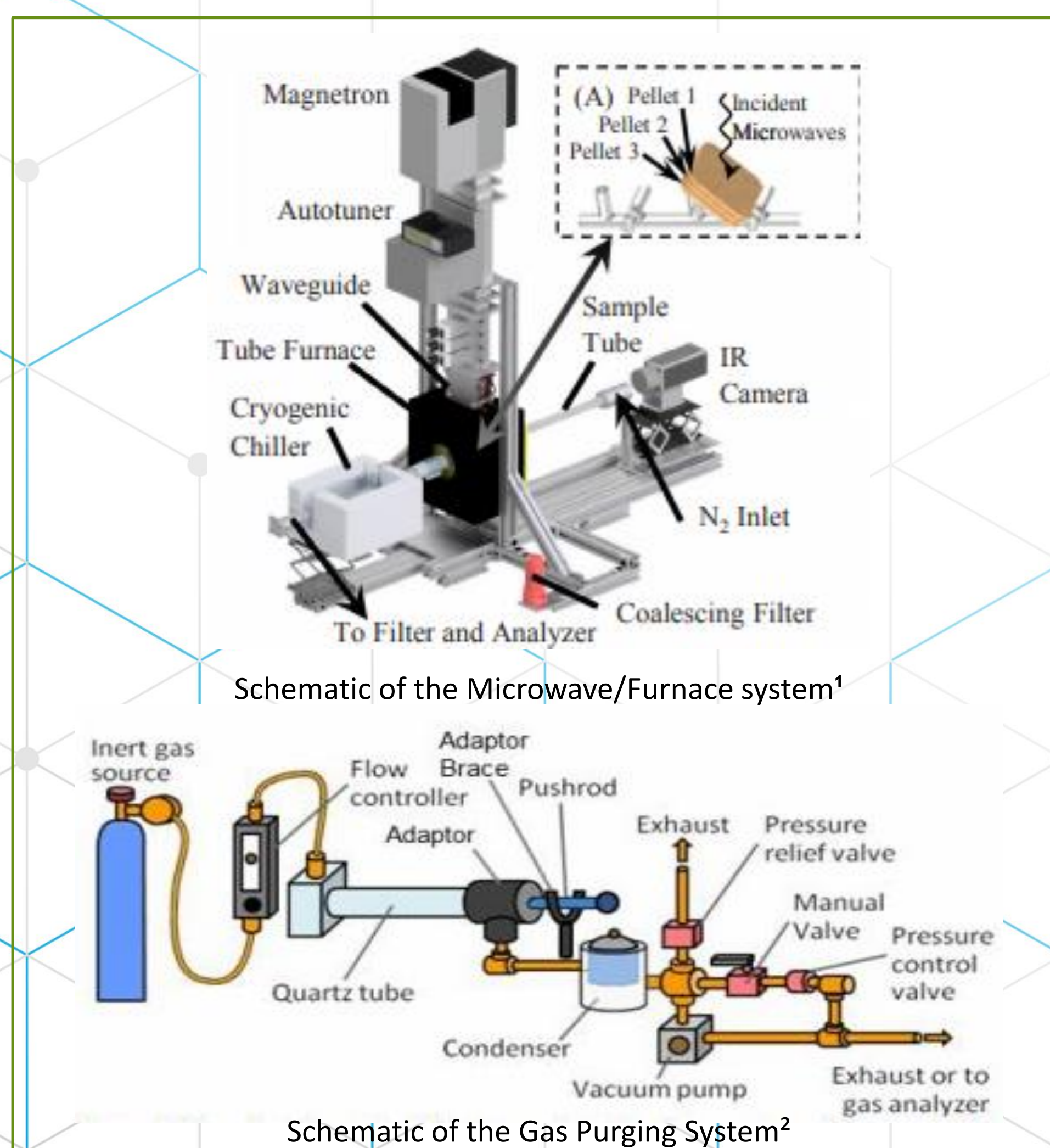
## My Goal:

To produce more or an equivalent amount of fuel from the same amount of biomass while eliminating as much human error as possible from the collection of data/test phase.

## Materials/Equipment:

- 2 mm Pine Wood Chips
- Activated Charcoal (Used to absorb microwaves and speed up heating process)
- Biomass Pellets (1.5g, 1.5 cm x 1.5 cm x 0.7 cm : 1.0g, 1.5 cm x 1.5 cm x 0.5 cm)
- 364 cm<sup>3</sup> quartz cylinders
- A Vacuum Adapter/Push Rod
- Fast Microwave Pyrolysis Generator/Controller
- Dry Ice (Condenser)
- Infrared Camera (FLIR)
- Computer/Camera Control

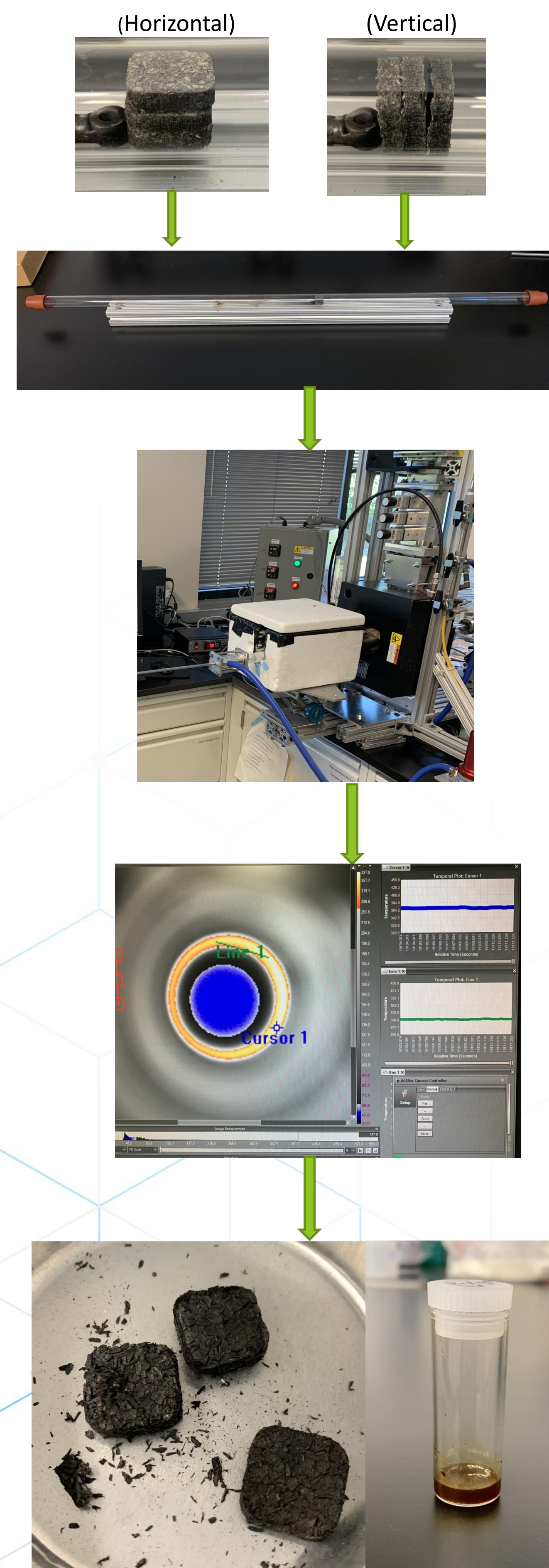
## Equipment Set-up



## Experimental Approach:

The goal of the experiment is to heat 3.0 g of biomass with 2.5% charcoal at a rate of 10 °C/s up until the sample rests at 500°C.

## Procedure:



1. Set up either two 1.5g pellets or three 1.0g pellets in the same position as either of the pictures to the left.

2. Place pellets within the quartz test tube.

3. Insert test tube into microwave furnace. Seal with vacuum adapter, attach hose to gas analyzer, begin Nitrogen gas purge flow. Set up a condenser with dry ice (the white Styrofoam box).

4. Push pellets into test chamber via Push Rod/Vacuum Adapter. Begin test recording. Control microwave application and measure pellet temperature via IR camera control as shown on the left.

This step can result in disposition of vertical pellets. This is the "human error" in the experiment.

5. Remove pellets from test chamber after microwave application and wait for 600 s test time to end. Wait for non-purge gas levels to drop. Remove quartz cylinder and collect Bio-Char and Bio-Oil.

## Yield Results:



\*Data below represented left to right: (1.0g Vertical, 1.0g Horizontal, 1.5g Vertical, 1.5g Horizontal)  
Oil Yield Averages/Errors: 59.51% ± 2.2% , 60.63% ± 0.6%, 55.61% ± 5.0%, 58.30% ± 2.0%  
BioChar Yield Averages/Errors: 21.35% ± 3.4, 22.13% ± 4.7%, 28.64% ± 6.0%, 23.45% ± 1.0%  
Gas Yield Averages/Errors: 19.15% ± 5.1%, 17.24% ± 4.9%, 15.65% ± 3.0%, 18.25% ± 1.0%  
Number of Trials per Position: 4,4,4,3

## Observations:

- Temperature readings made off a single point or a line averaging the temperature covered by its area.
- From the camera's perspective, there is uneven heating from the furnace alone.
- Temperature increases much quicker on the North-East section of pellet.
- Relied on average temperature from the "line" graph.
- This technique was only completely reliable with the vertical pellets.
- Horizontal pellets had gaps within the surface presented to the camera.
- These gaps affected average temperature for the line graph, making accurate data observation slightly more difficult.
- However, horizontal pellets never became dispositioned due to push rod.
- Horizontal pellets on bottom of stack did not go through complete pyrolysis.

## Analysis:

- The horizontal orientation of three 1.0g pellets produced the most the most oil per gram.
- The 1.0g, horizontal pellets had a 1.12% increase in yield in comparison to the three, vertical, 1.0g pellets.

## Conclusion:

Based off these observations and data, a preliminary conclusion can be made about the orientation of biomass pellets and their yields when having experienced fast microwave pyrolysis. For the greatest yield in oil from 3g of biomass with 2.5% charcoal, having three 1g pellets stacked horizontally or vertically will not cause a significant difference in oil yield. Although, the horizontal pellet method is much easier to execute and can save up to an hour of time in the worst situation. This conclusion is based off the data within this poster alone and more testing would need to be done to confirm the validity of this information.

## References:

1. Klinger J. Effect of biomass type, heating rate, and sample size on microwave-enhanced fast pyrolysis product yields and qualities, Fig. 1. *Applied Energy*. 2022; Volume 324.
2. Thomas B. Performer controlled activity assessment: operation of microwave-enhanced fast pyrolysis reactor, Figure 2. *LST* – 889. 2022; Volume 18.