Argon Atmospheric Microwave Plasma

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INTRODUCTION: Plasma gasification of biomass is emerging as an efficient way to reduce the carbon foot print of waste disposal while producing renewable energy. In order to improve the plasma gasification system, modeling is done to explore a paramount approach. This poster presents an investigation into the relationship of microwave power, electron density, and surface temperature using COMSOL Multiphysics™ version 5.3a. These results along with others will be the foundation to future experimental testing which has the potential to redefine and improve microwave plasma gasification for distributed electric power generation. The end goal is to provide a reduction of the cost of electricity around the world.

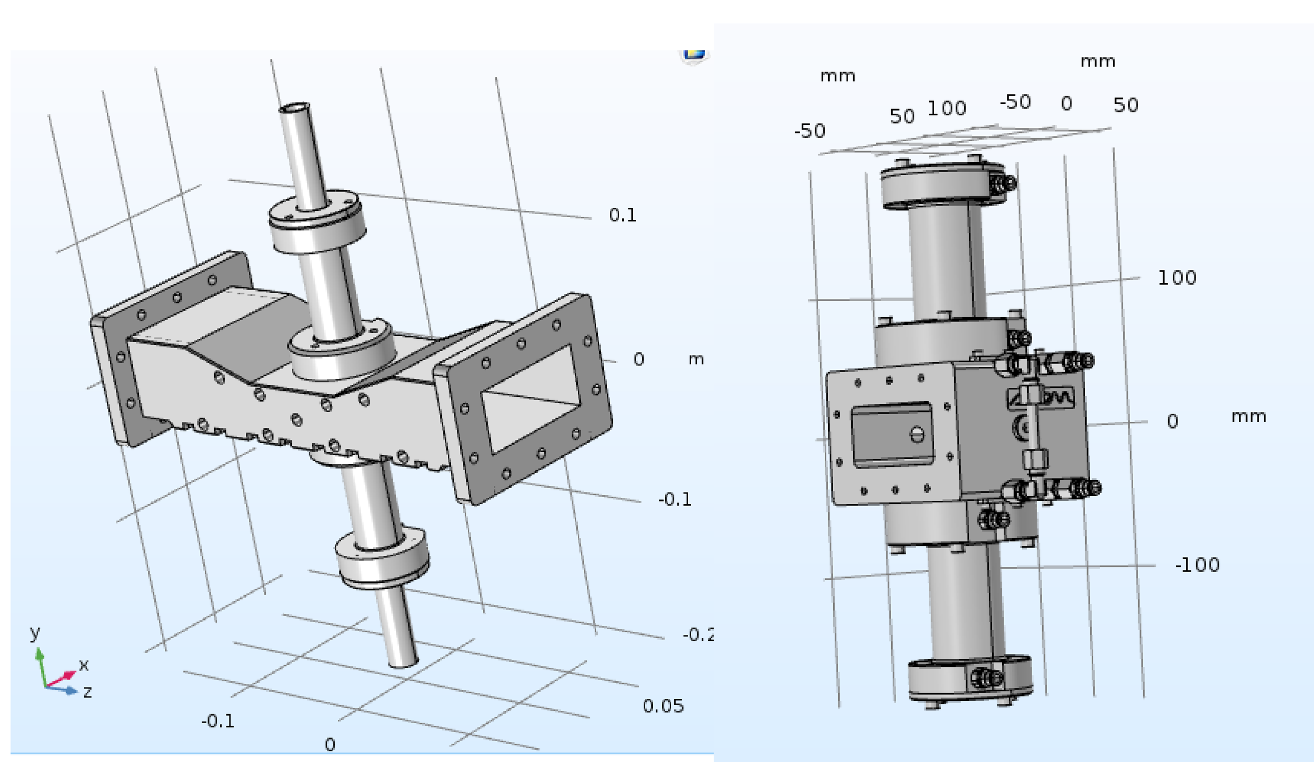

Figure 1: Downdraft options for the improvement of microwave assisted plasma gasification.

DATA REQUIRED FOR MODELNG: Before attempting to model plasma there is critical information that needs to be assembled in regards to the chemical processes that occur in plasmas. This critical information includes:

1) A set of electron impact reactions
2) Rate coefficients for each reaction
3) Applicable surface reactions, sticking coefficients, rate coefficients, and secondary electron emission probability.
4) Thermodynamic property data

Aside from the aforementioned information there are some foundational parameters that are also used in our model. They are as follows:

Name	Expression	Unit
Gas Temperature	300	K
Pressure	760	Torr
Gas Velocity	0.345	m/s
Microwave Frequency	2.45	GHz
Power	300-3000	W

PLASMA CHEMISTRY
For this simulation, plasma is modeled as a fluid, which contains electrons and ions. Reaction types include excitation, ionization, elastic, super elastic, penning ionization, metastable quenching, ion conversion, dissociative recombination, 3 body reaction, and surface reactions.

RESULTS: The following 2D surface plots were produced as a part of the post processing results in order to find a relationship between power, ionization, and temperature.

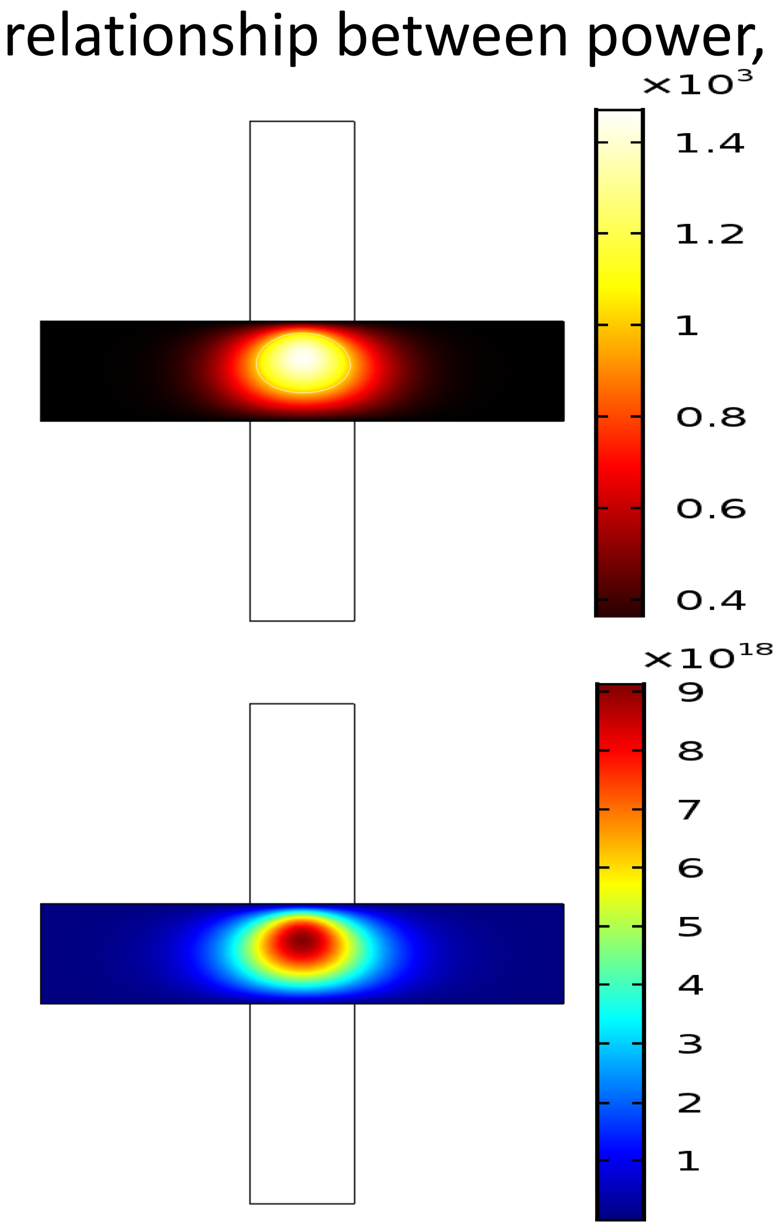

Figure 2: Top Surface Temperature (K)
Bottom Surface: Electron density ($1/m^3$) at 300W

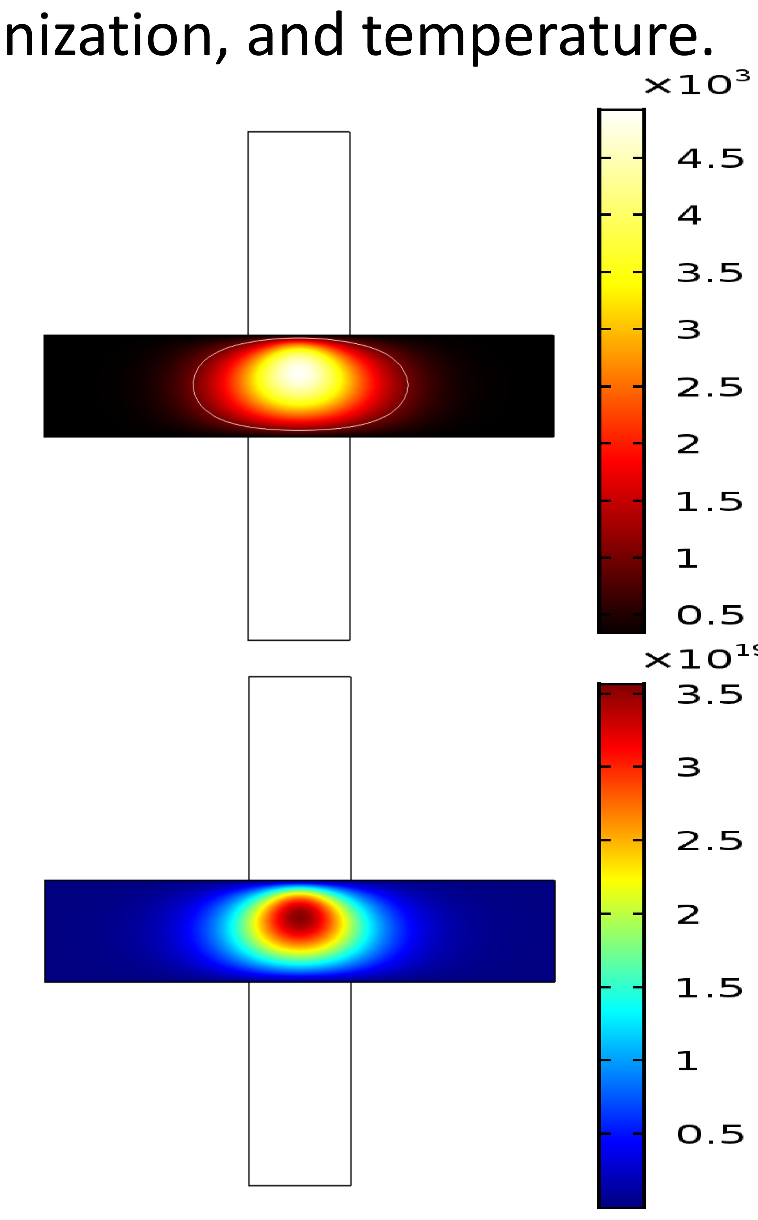

Figure 3: Top Surface Temperature (K)
Bottom Surface: Electron density ($1/m^3$) at 1200W

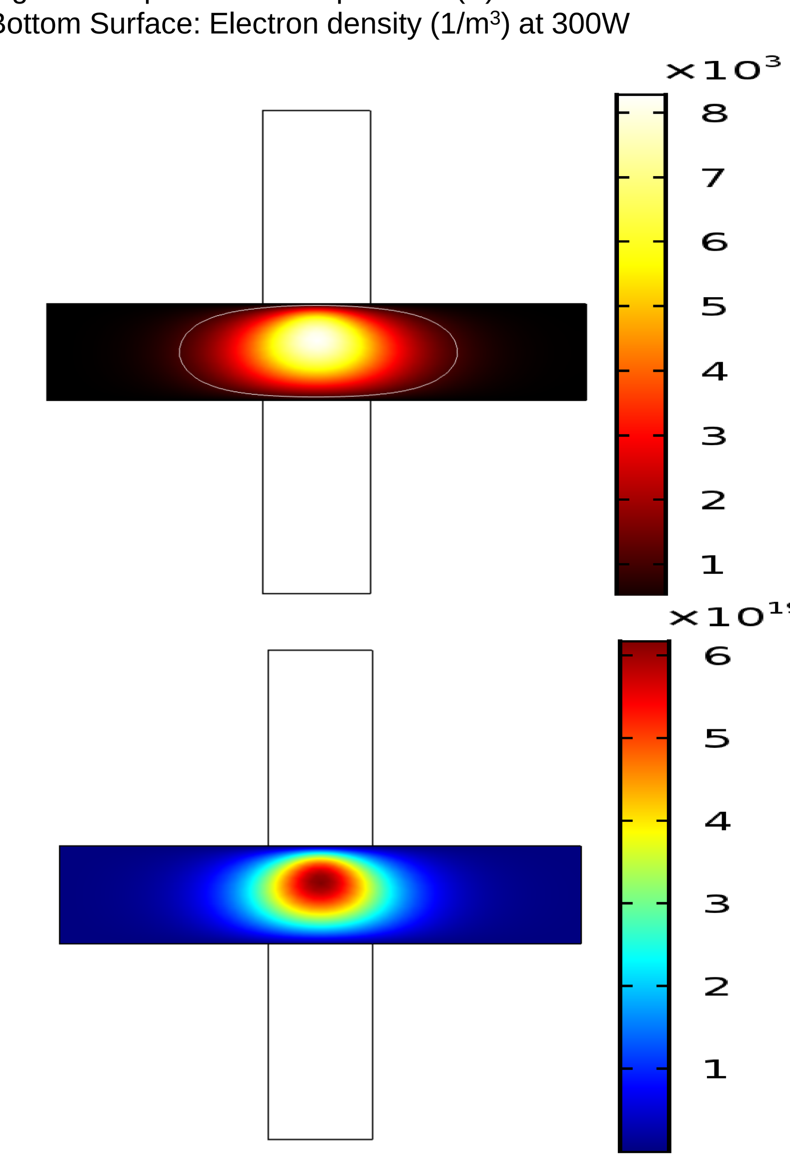

Figure 4: Top Surface Temperature (K)
Bottom Surface: Electron density ($1/m^3$) at 2100W

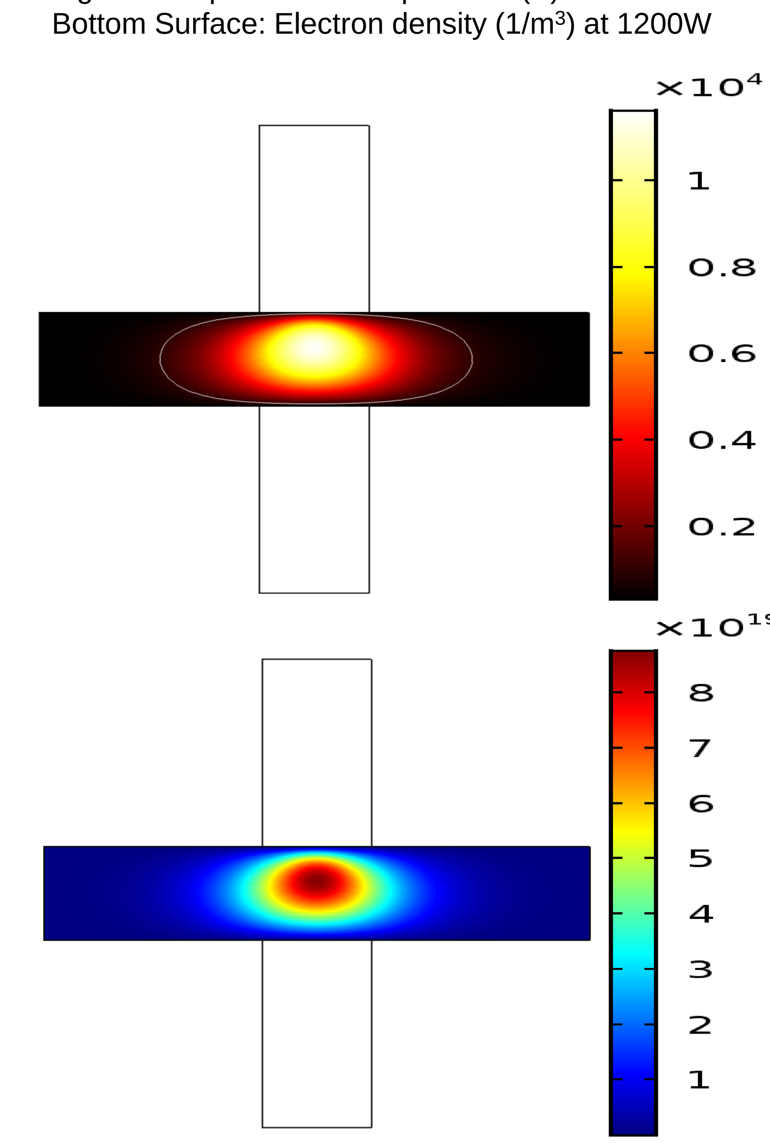

Figure 5: Top Surface Temperature (K)
Bottom Surface: Electron density ($1/m^3$) at 3000W

CONCLUSIONS: These results are a way of producing relatively cheap iterations of possibilities for improvement. The figures above show that as power is increased, electron density along with temperature increase. With this relationship it will now be easy to determine the amount of power needed to reach a specific temperature to most efficiently convert specific types of solid biomass into synthesis gas with minimal waste in energy. An experimental design based off these models will further validate the MDP system design and provide a foundation for more efficient future commercial designs.

If you have question about this project please reach out to us! Tressa.Marquardt@mnsu.edu or Danayit.Shewamene@mnsu.edu
Interested in supporting this research or partnering? Ask us how- Jacob.Swanson@mnsu.edu

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