COMPUTER SIMULATIONS OF OXY-COAL COMBUSTION SYSTEMS

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OBJECTIVES

- Reduce carbon emissions and promote sustainable use of fossil fuels by determining the most efficient coal combustion process through the manipulation of various parameters.
- Observe the impact of oxidant concentrations in oxy-coal combustion systems on flame length and stand-off distance (the distance from the ignition point and the tip of the burner).

Coal $\xrightarrow[heat]{O_2}$ Ash + CO_2 + H_2O

- In order to achieve these goals, we will use computer models to simulate combustion.

BACKGROUND

- Traditional coal combustion methods burn fuel with air to generate usable energy. Because air is composed in large part of nitrogen, the fuel cannot be burned as efficiently and nitrogen oxides (NO_x) are produced.

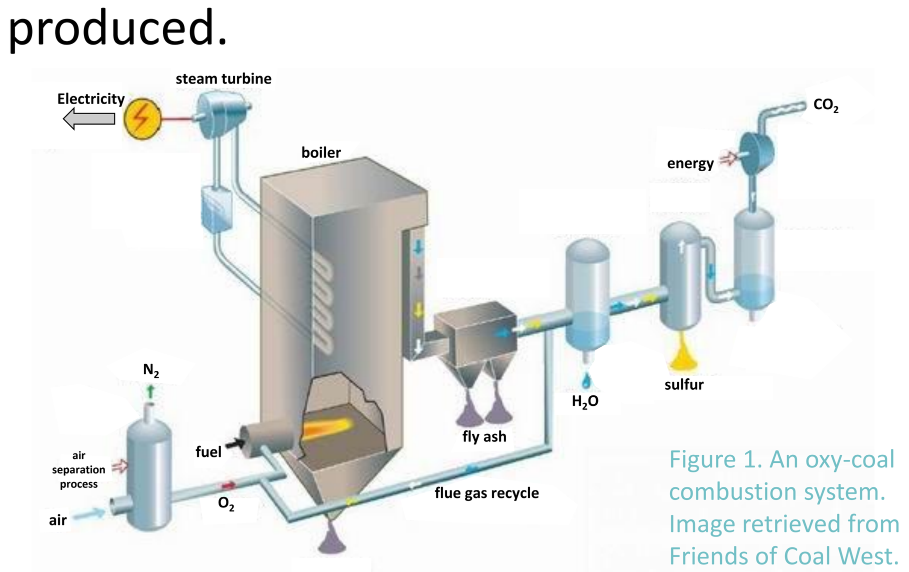


Figure 1. An oxy-coal combustion system. Image retrieved from Friends of Coal West.

- Oxy-coal combustion, an environmentally friendly coal combustion method, allows the CO_2 to be recycled back into the system, thus reducing carbon emissions.
- Flame stability is greatly dependent on the O_2 concentration in the boiler's primary burner.

COMPUTATIONAL METHODS

- ANSYS Fluent, a computational fluid dynamics software, is utilized to visualize the flame stand-off distance in coal combustion from different concentrations of oxygen and carbon dioxide in the primary burner, ignition and radiation zone wall temperatures of 1283 K, and two coals of varying composition:

Utah bituminous coal **Illinois #6 coal**

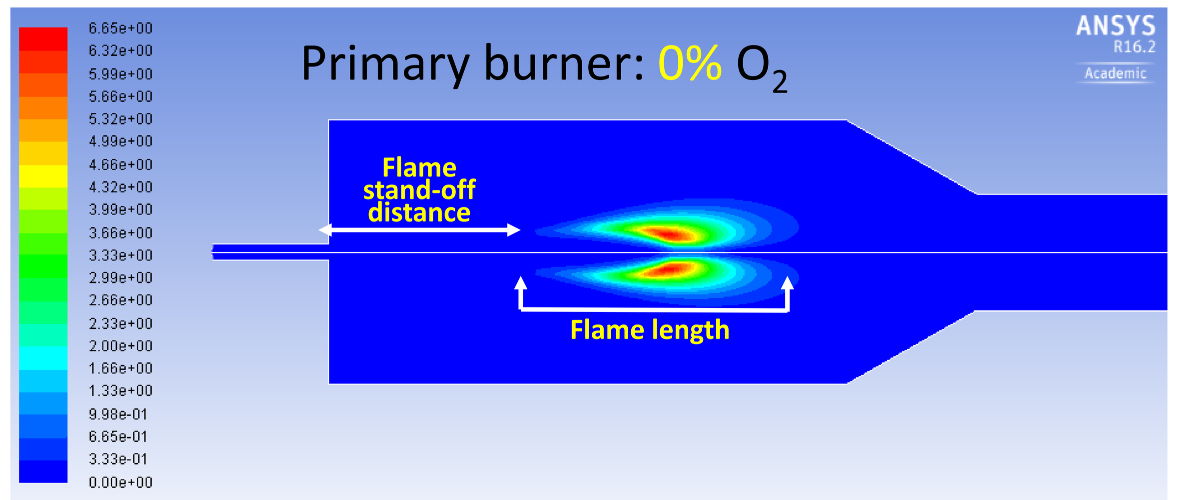
- Boundary conditions were altered in order to demonstrate the impacts of certain variables on the flame and overall system output. The boundary conditions on which we focused are as follows:

- Wall temperature
- Primary burner temperature
- Primary burner O_2 concentration
- Mass flow rate (introduction of coal to the system)
- Burner velocity (oxidant velocity)
- Primary burner CO_2 concentration

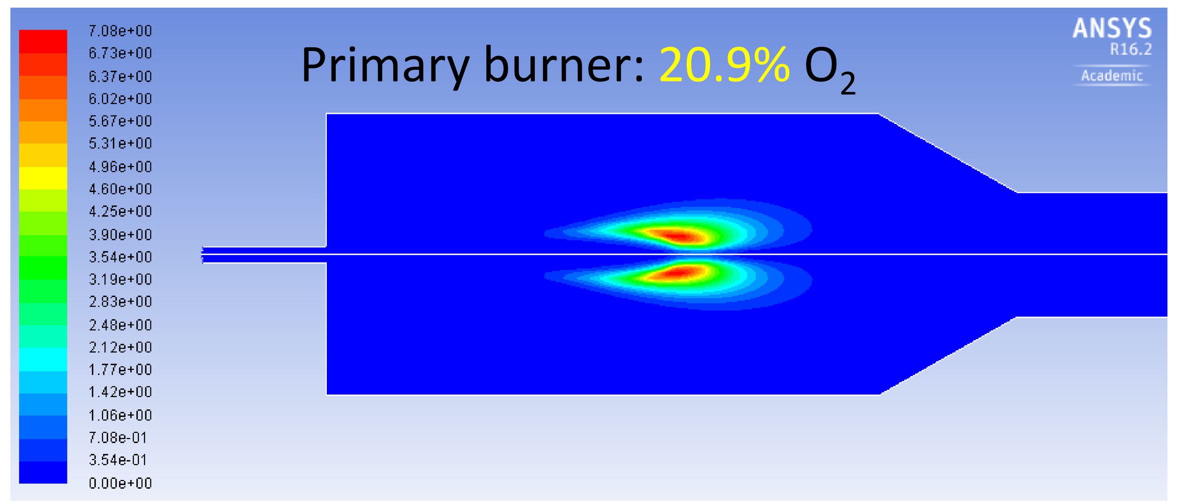
HEAT OF REACTION CONTOURS

UTAH BITUMINOUS COAL

Wall Temperature = 1283 K



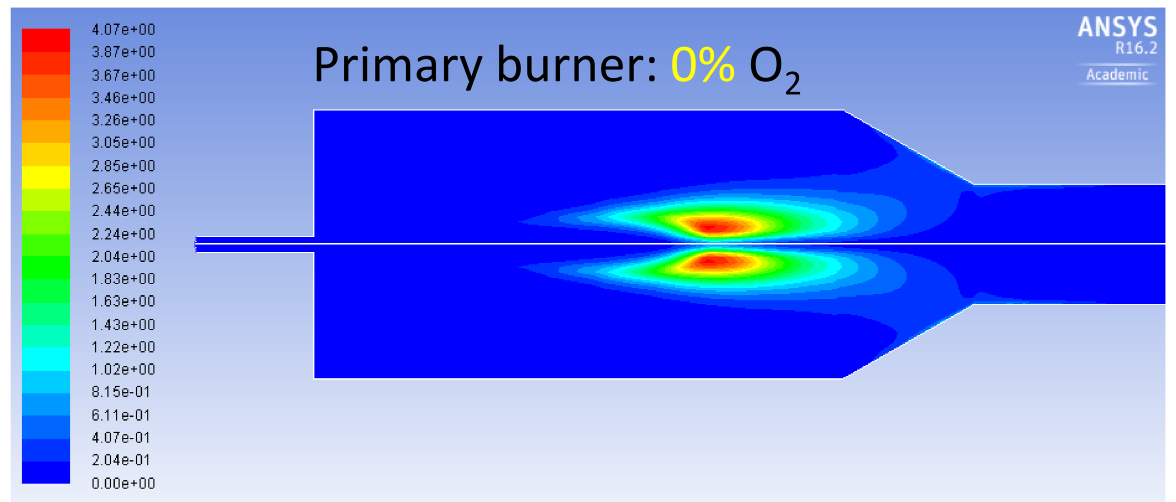
Flame Length: 0.51 m
Flame Stand-off Distance: 0.52 m
Maximum Temperature: 1400 K



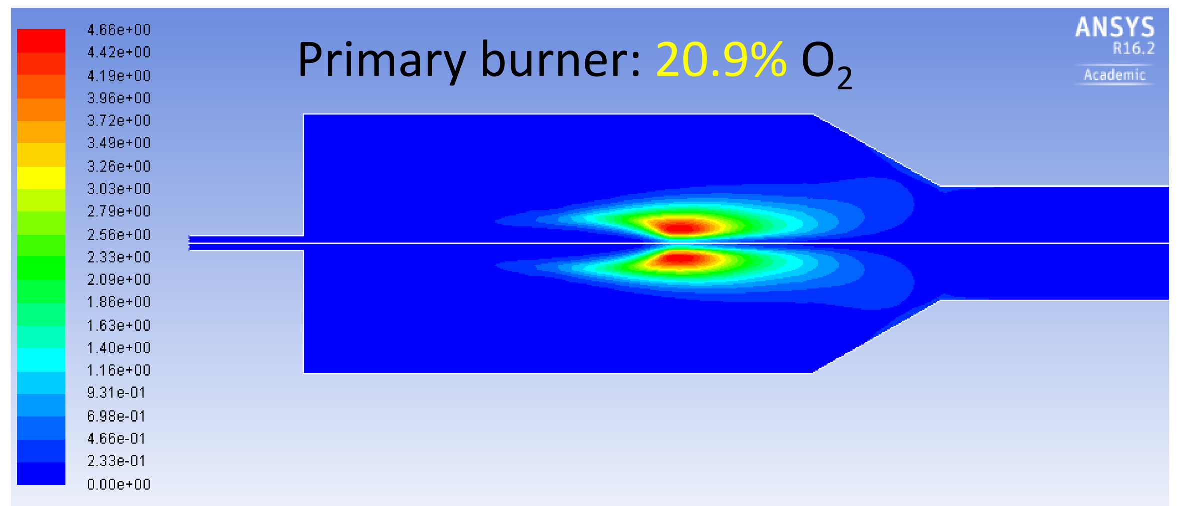
Flame Length: 0.48 m
Flame Stand-off Distance: 0.51 m
Maximum Temperature: 1400 K

ILLINOIS #6 COAL

Wall Temperature = 1283 K



Flame Length: 1.16 m
Flame Stand-off Distance: 0.55 m
Maximum Temperature 1460 K



Flame Length: 0.96 m
Flame Stand-off Distance: 0.54 m
Maximum Temperature: 1500 K

CONCLUSIONS

- The flame stand-off distance decreases due to faster diffusion as the concentration of oxygen increases in the primary burner, resulting in increased flame stability and more efficient coal combustion.
- The flame length decreases as the concentration of oxygen in the primary burner increases, which agrees with prior experimental data.
- Quantum Espresso, a theoretical chemistry software, will be used to demonstrate the activity of metal oxides SiO_2 and MgO when produced in the recycled flue gases during oxy-coal combustion.

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