Abstract: In this rapidly growing world we find ourselves depleting many of our non-renewable resources at rapidly alarming rates. In order to secure supplies of commodities and essentials, such as fuel and plastics, new renewable alternative fuel sources must be explored. One such source is the process of converting biomass to bio-oil. This process uses mechanical systems such as a fluidized bed reactor or an auger reactor, these thermal reactors use the process of fast pyrolysis to thermally breakdown the biomass and then condense the resulting vapors to create bio-oil.

Research Goal: Compare the variations in yields of bio-oil, NCG, and bio-char from each thermal reactor and the composition of the products.

Background: Why is this research being done? The answer is because the U.S. is consuming oil at all-time highs and is not slowing down. The United States spends several billions a year importing oil while depleting oil reserves. President Barack Obama has proposed a plan to replace 50% of all imported oil with American-made alternative fuels by the year 2020.[1] One solution is the conversion of biomass to bio-oil using fast pyrolysis. Fast pyrolysis is the thermal decomposition of organic compounds in the absence of oxygen to produce liquids, gases, and bio-char.[2] Iowa State University is conducting research using thermal reactors to determine which produces the best yields and quality of bio-oil. The two main types of reactors are fluid bed (Figure 1) and auger (Figure 2).

The fluid bed reactor uses a fluidizing sand bed to convert the biomass to vapors, while the auger reactor uses two augers to mix the biomass with an external heat carrier such as stainless steel. The vapors from both reactors are condensed using similar techniques, vapors go through a cyclone to remove char, an Electrostatic Precipitator (ESP) to collect aerosols, and condensers to collect the remaining bio-oil. The NGCs are measured using a Micro GC. The products are then analyzed using analytical equipment for composition.

Methods:
1. Record the initial mass of all the parts
2. Purge N2(Nitrogen) through reactor to eliminate O2 (Oxygen)
3. Calibrate the reactor
4. Add precise amount of biomass into biomass feeder
5. Assemble final parts of reactor(connector hoses, compressors, seals, safety shields, etc…) and connect computers
6. Heat up reactors to steady state temperature
7. Set reactor to run a certain amount of time at a precise temperature, flow, and feed rate
8. Record final mass of all the parts
9. Make yield calculations

Results:

Discussion: From the information in the charts it can be seen that both reactors produce approximately the same yields in all areas with mostly minor differences. The composition of both oils are comparable with similar amounts of Levoglucosan(a key chemical in bio-oil). An issue with bio-oil reactor plants is that unlike oil refineries they don’t have an exponential growth factor because they have to operate at an optimal size due to the fact that the price of transporting the biomass increases at larger distances[3]. The research conducted this summer will help with the development of bio-oils with greater efficiency. The experience from this research has helped me better understand a certain area of mechanical engineering and how it greatly overlaps with other fields such as chemistry.

References:
Thermological Processing of Biomass
Conversion into Fuels, Chemicals and Power
Establishing the optimal sizes of different kinds bio refineries

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