Pilot Scale Continuous Pyrolysis of Pinus Radiata Sawdust

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Outline
• Project background
• Pyrolysis overview
• Feedstock characterisation
• Pilot plant trials
  • Effects of variables on process-ability
  • Effects of variables on product yields
• Process economics
• Conclusions
• Future research
**Project background**

- Prospective client approached Lakeland Steel Limited for mobile pyrolysis plant feasibility assessment

**Technical Trials**
- Lab-scale
- Lakeland steel pilot plant
- Effects of pre-drying feedstock, variation of feed rate and reactor temperature.

**Economic Feasibility**
- Identify major variables affecting feasibility

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**Pyrolysis overview**

Pyrolysis is the decomposition of carbonaceous matter under heat in the absence of oxygen.

Key parameters of this process include:
- Feedstock type
- Reaction temperature
- Residence time
- Heating rate

The yields of these products can be tweaked depending on the key parameters.
Feedstock characterisation

- Proximate & ultimate analyses
- Drying characterisation
- Thermogravimetric Analysis (TGA)

These were used to justify temperatures used in pilot trials and large scale design.

Pilot plant trials

<table>
<thead>
<tr>
<th>Level</th>
<th>Moisture (%)</th>
<th>Temperature (°C)</th>
<th>Throughput (hertz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>15%</td>
<td>400</td>
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<td>30%</td>
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<tr>
<th>Factor B</th>
<th>Factor C</th>
<th>Factor A</th>
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Effects of processing parameters on processability

- 15% and 30% moisture feedstock flowed through reactor consistently.
- 60% moisture feedstock caused blockages
- Higher moisture content reduced feedstock flow properties due to lubricating effect.
- Higher producer gas fraction

Effects of moisture variation
Effects of temperature variation

- Increase in flame height suggesting higher volume flow rate. Confirmed by rotameter readings
- More tar formed at 400°C
- More oil at 450°C
- More Syngas at 500°C

Effects of reactor auger speed

- Increased speed produced less cooked char
- Higher char volume
- However, increasing speed to values of 30-50 after reactor is operating at steady state increases the rate of gas evolution
Blockages

Loose sawdust being fed through bulk density 280 kg/m³

Dry compacted sawdust prior to decomposition, bulk density 1,202 kg/m³

Effects of process parameters on product yield
Effects of moisture variation

- Char yield %: 38.37%, 48.01%, 36.35%
- Oil yield %: 15%, 23.14%, 46.01%
- Gas yield %: 40.51%

Effects of temperature variation

- Char yield %: -10%, 0%, 10%
- Oil yield %: 40%, 45%, 50%
- Gas yield %: 50%, 60%, 70%
Effects of reactor auger speed

- Char yield %
- Oil yield %
- Gas yield %

Process economics

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Optimistic Case</th>
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</thead>
<tbody>
<tr>
<td>Processing Capacity (Tpa)</td>
<td>29,000</td>
<td>29,000</td>
</tr>
<tr>
<td>Capital ($)</td>
<td>736,489</td>
<td>595,783</td>
</tr>
<tr>
<td>Operating ($ /ton)</td>
<td>1,207,409</td>
<td>633,989</td>
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<tr>
<td>Revenue ($/ton)</td>
<td>787,215</td>
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<tr>
<td>Annual Cash flow ($/yr)</td>
<td>(420,194)</td>
<td>153,226</td>
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<tr>
<td>Payback period (yrs)</td>
<td>N/A</td>
<td>3.89</td>
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</table>
Conclusions

- Increase in moisture content increases tendency of blockages for the temperatures used.
- Process economics are still not favourable however, potential for viability depends on the selling of biochar and development of low cost technology.

Future research

- Global Model to accurately describe the pyrolytic conversions on a pilot scale.
- Pilot plant run for a significant amount of time to improve operating cost data.
Ministry of Science and Innovation (MSI)

Dr Mark Lay  
*University of Waikato*

Cory Leatherland  
*General Manager of Lakeland Steel Limited*

Other Staff and Students who helped along the way

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**Pyrolysis product applications**

**Char**
- Soil amendment
- Low sulfur fuel
- Water/air filtering medium once activated
- Catalyst support
- Traditionally used as antidote
- Reducing agent

**Bio-oil**
- Is composed of many hydrocarbons such as acetic acid
- Can be upgraded to biodiesel
- In some cases can be burned as fuel

**Syngas**
- A “cleaner” fuel replacement for LPG or natural gas
- Used for electricity generation
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