





# 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



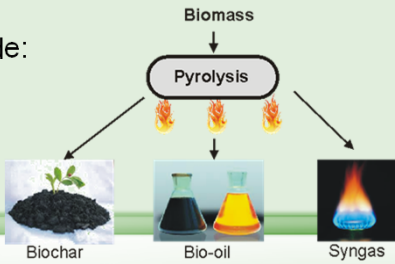
## Pyrolysis overview



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




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graph TD
    Biomass --> Pyrolysis
    Pyrolysis --> Biochar
    Pyrolysis --> Biooil[Bio-oil]
    Pyrolysis --> Syngas
    
```

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




Level	Moisture (%)	Temperature (°C)	Throughput (hertz)
0	15%	400	15
1	30%	450	20
2	60%	500	25

		Factor A		
Factor B	Factor C	0	1	2
0	0	000	100	200
0	1	001	101	201
0	2	002	102	202
1	0	010	110	210
1	1	011	111	211
1	2	012	112	212
2	0	020	120	220
2	1	021	121	221
2	2	022	122	222








## Effects of processing parameters on processability



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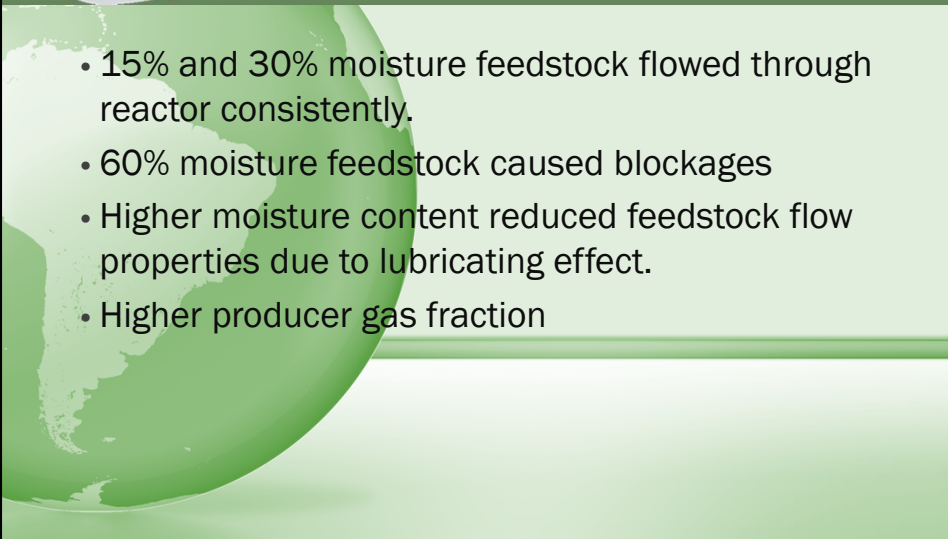



## Effects of moisture variation




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- 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 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  $280 \text{ kg/m}^3$




Dry compacted sawdust prior to  
decomposition, bulk density  $1,202 \text{ kg/m}^3$

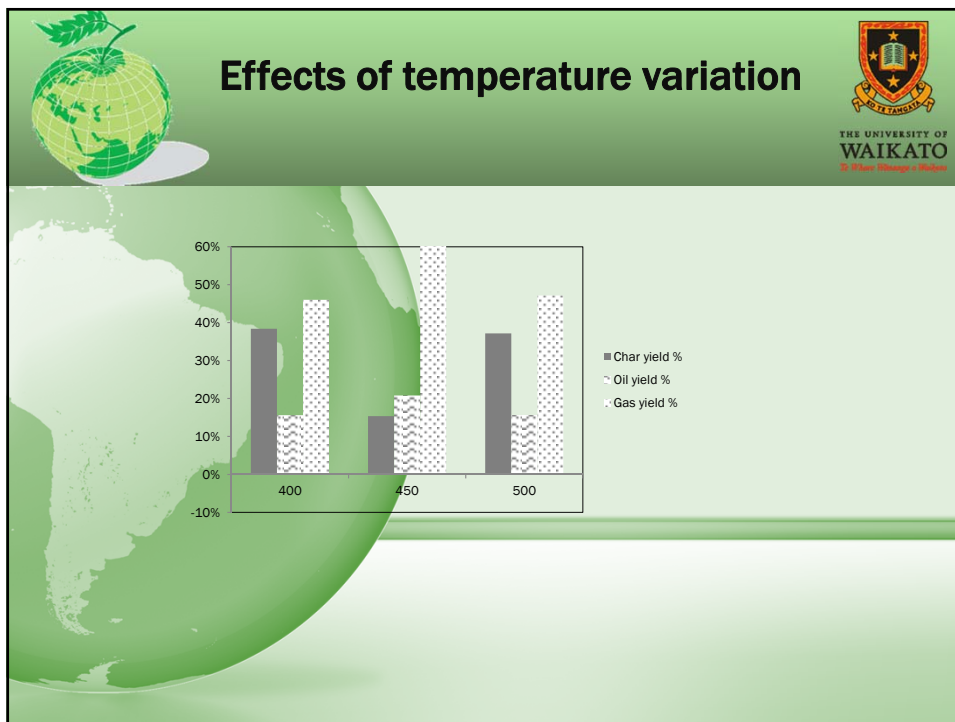
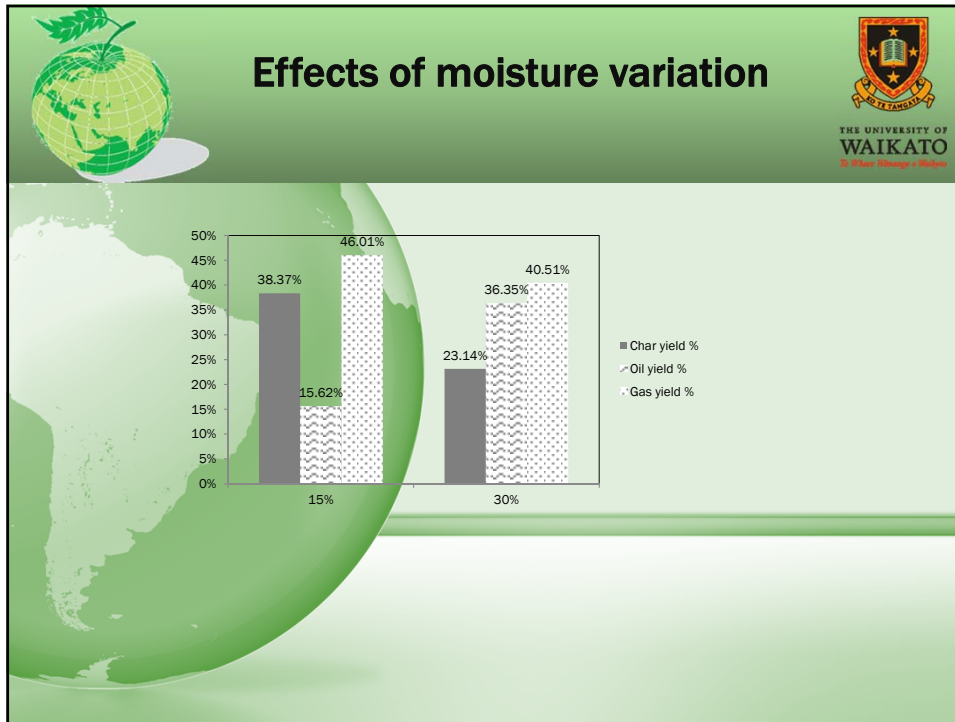


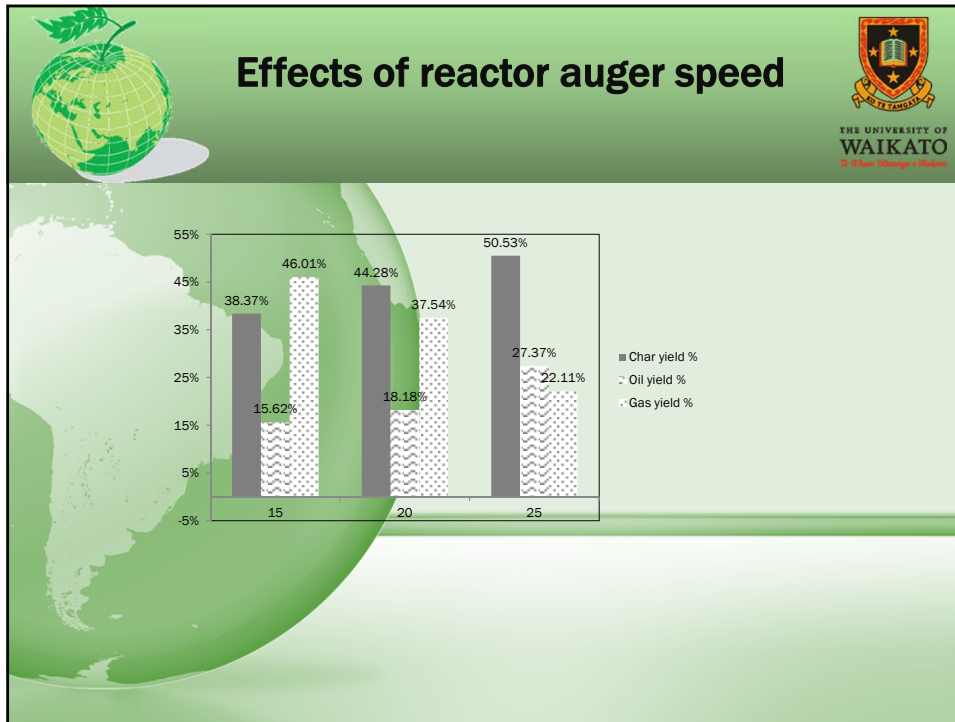
## Effects of process parameters on product yield













### Process economics

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







## 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**

**Pyrolysis product applications**

<p><b>Char</b></p> 	<p><b>Bio-oil</b></p> 	<p><b>Syngas</b></p> 
<ul style="list-style-type: none"> <li>• Soil amendment</li> <li>• Low sulfur fuel</li> <li>• Water/air filtering medium once activated</li> <li>• Catalyst support</li> <li>• Traditionally used as antidote</li> <li>• Reducing agent</li> </ul>	<ul style="list-style-type: none"> <li>• Is composed of many hydrocarbons such as acetic acid</li> <li>• Can be upgraded to biodiesel</li> <li>• In some cases can be burned as fuel</li> </ul>	<ul style="list-style-type: none"> <li>• A "cleaner" fuel replacement for LPG or natural gas</li> <li>• Used for electricity generation</li> </ul>



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