Mixing and operability characteristics of mechanically fluidized reactors for the pyrolysis of biomass

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Mixing and operability characteristics of mechanically fluidized reactors for the pyrolysis of biomass

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Technology developed at ICFAR

- Previously used for batch pyrolysis at 0.1 kg/hr scale

→ continuous, 1 kg/hr scale?

Advantages over standard fluidized bed pyrolysis:

- No fluidization gas required
  - Simpler, cheaper, more effective condensation train
  - Less energy
- No sand bed:
  - Pure char product
Reactor volume = 4.4 liters
• Sand ($d_{psm} = 190 \, \mu m$) for initial testing to get reproducible preliminary results

• Wood pellets

• Nitrogen to simulate fluidization

• Power consumption meter
PRELIMINARY TEST FOR MIXING

CHAR AND SAND MIXING vertical blade stirrer

- Layer of char on top of a bed of sand
- 98 rpm with additional gas ($\leq U_{mf}$)
- Visual observation $\rightarrow$ good mixing in less than 20 s!
POWER CONSUMPTION

SPIRAL STIRRER cold test run

Operation without gas is impractical
POWER CONSUMPTION

VERTICAL BLADE STIRRER at 550 °C

![Graph showing power consumption vs N₂ flowrate at 32 RPM and 152 RPM.]
• Can gas and vapors evolution during pyrolysis minimize power consumption?

• How crucial is mixing to the rate of pyrolysis? (literature: faster pyrolysis is better for liquid production and quality)

Pyrolysis of wood pellets at 550 °C without additional gas
PYROLYSIS STUDY at 550°C

PULSE OF BIOMASS WITH VERTICAL BLADE STIRRER

Power consumption is minimized!

98 rpm

200 s

Minimum P/P*
EFFECT OF RPM ON MIXING (vertical blade stirrer)
SIMULATION OF CONTINUOUS FEEDING

Vertical blade stirrer

Series of pulses → 0.27 g/s
CONCLUSIONS

• Good mixing in MFR required to achieve fast pyrolysis

• Current mixer good, but should be improved

• Gas and vapor evolution during pyrolysis:
  ➢ Greatly reduces power consumption
  ➢ Allows for future use of more sophisticated and effective mixers
FUTURE WORK

- Develop a more effective stirrer
- Effect of particle size on MFR pyrolysis
- Compare bio-oil yield and quality with standard fluidized bed pyrolysis
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