Measurement and Characterization of Temperature and Pressure in the Pelletization Process

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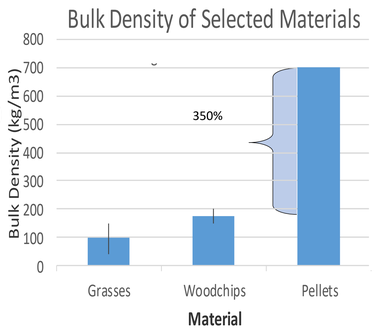
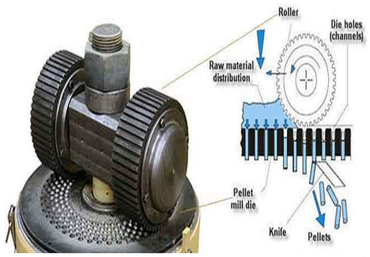
Challenges in Loose Biomass Logistics

- Significant costs are incurred during handling and transportation, and storage of biomass due to low bulk density (about 100 – 200 kg/m^3) and high moisture content (>15% w.b.) of biomass.
- **Pelletization is one of most commonly used biomass densification methods for overcoming these challenges.**





Biomass Pelletization

Consists of three major unit operations:

- Drying of bio-feedstock
- Size reduction (grinding)
- Thermo-mechanical compaction

Variables in Pelletization System

- Process variables:
  - Pressure
  - Temperature
  - Die/Roller speed
- Feedstock variables:
  - Moisture content
  - Particle size and size distribution
  - Feedstock species
- Pellet quality attributes:
  - Bulk density
  - Durability
  - Pellet moisture content
  - Flow/handling characteristics

Challenges in Biomass Pelletization

- Relationships between biomass properties and pellet processing conditions are empirically understood
- There are frequent disruptions during pelleting process due to clogging and/or not forming pellets
- Biomass pellets sometimes suffer from poor pellet quality in the form of low durability or inferior strength
- Non-optimized performance of pellet mills consumes higher than necessary energy and maintenance efforts

Knowledge Gap

- Inadequate characterization of mechanical properties of bio-feedstock
- Limited quantitative information of quality control during biomass pelletization
- Insufficient understanding of pelletization process/system
- **Need to introduce engineering principles to bridge the knowledge gap and to improve palletization**

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Measurement of the Thermo-Mechanical Process of Pelletization

Research Goal

Implement a scientific approach to engineer current biomass pelletization practice to enable expanding the utility of abundant biomass as a renewable energy resource.

Objectives

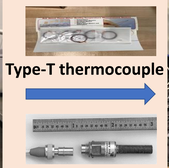
Measurement of physical and mechanical conditions of pelletization

- Instrument a pellet die with temperature and pressure sensors at multiple locations
- Measure temperature and pressure sensors during dynamic biomass pelleting processes with selected biomass species
- Compare result to modeled performance

Instrumentation of Stationary Die Pelletizer

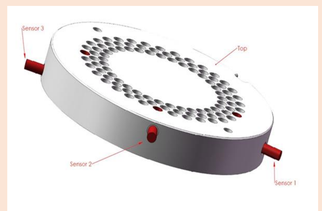
- Stationary Die Pelletizer

Flat-Die pelletizer (non-Instrumented)



Instrumented Pelletizer

- Schematic of pressure and temperature sensors locations



- Feedstock preparation and Size reduction

Bio-feedstock

Grinding machine

Granulated Feedstock

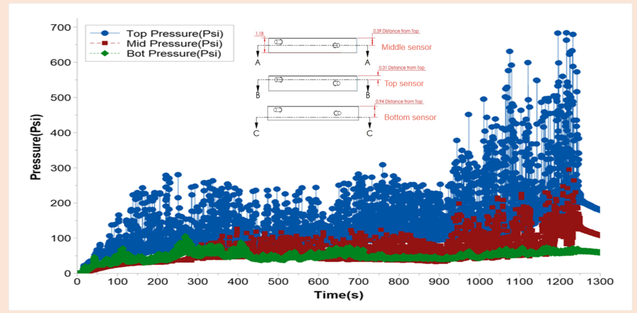
- Data Collection

CR23X Datalogger CAMPBELL SCIENTIFIC, INC.

GRAPHTEC Datalogger

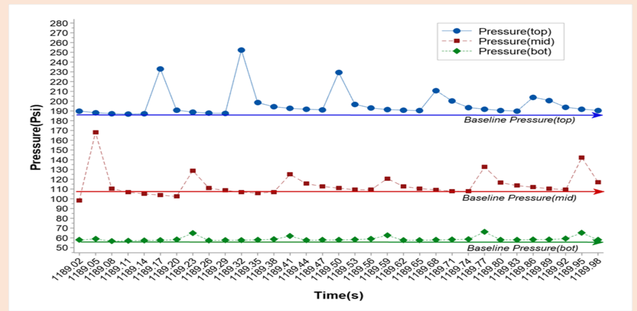
Experiment Results

Pressure



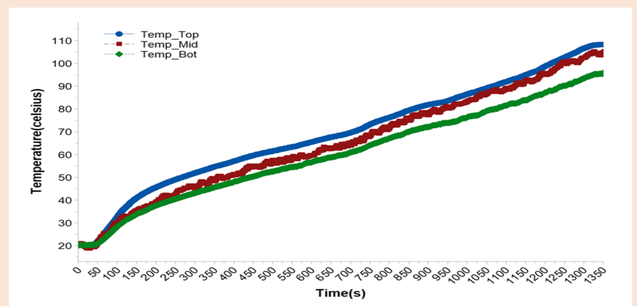
- Instantaneous Radial Pressure Vs. Time measured during pelletization using three sensors from top, middle and, bottom location of the die.

Pellets produced from the first phase with pre-mix (left), second phase (center), and third phase (right)



- Pressure reading collected during pelletization in 1 second with 0.03 s time step
- Instantaneous radial pressure reading increase periodically vs. time.
- Baseline radial pressure decreases along the depth of the die hole.

Temperature



- Temperature vs. time measured during pelletization using three thermocouples from top, middle and, bottom location of the die.
- Temperature decreases along the depth of the die hole.
- Temperature increases when pressure and processing time increases.