Milling of Utah, Sufco Coal with 15% Prepared Manti-La Sal Woody Biomass in a Raymond Bowl Mill

Andrew Fry, Seyedhassan Fakourian

Brigham Young University

Eric Eddings, Zsolt Dobó

University of Utah

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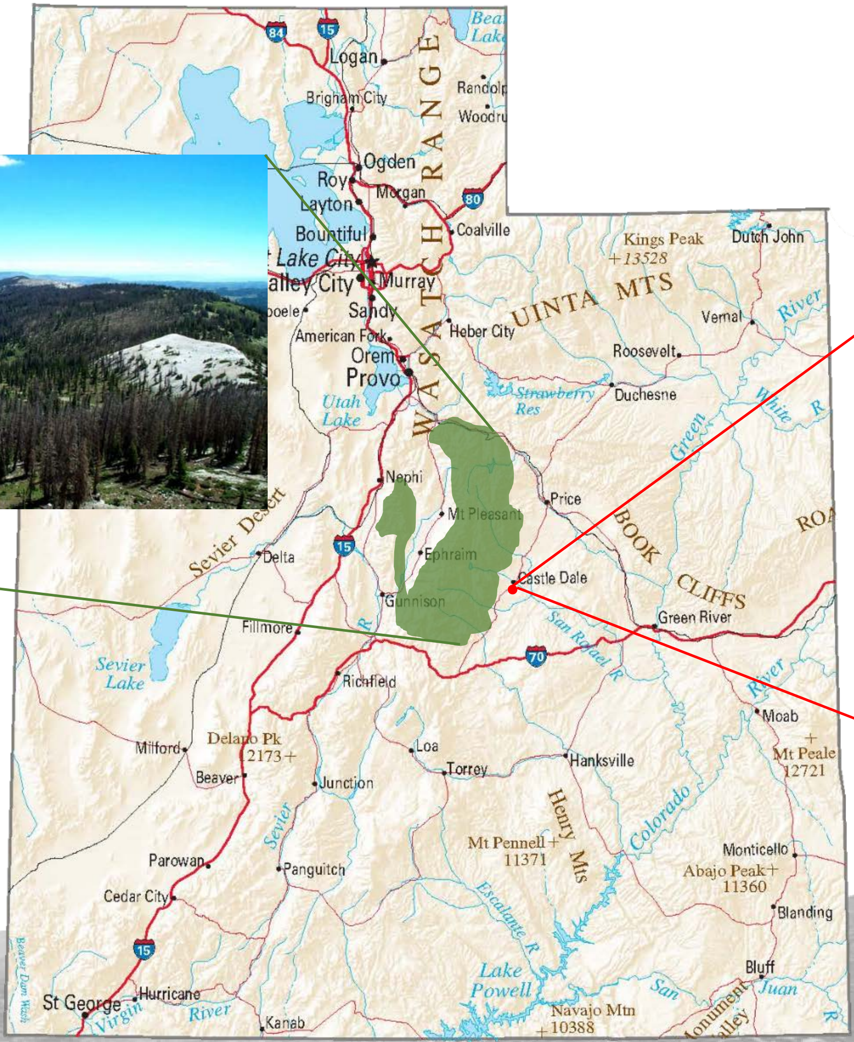
Introduction: Beetle Kill, Manti – La Sal National Forest

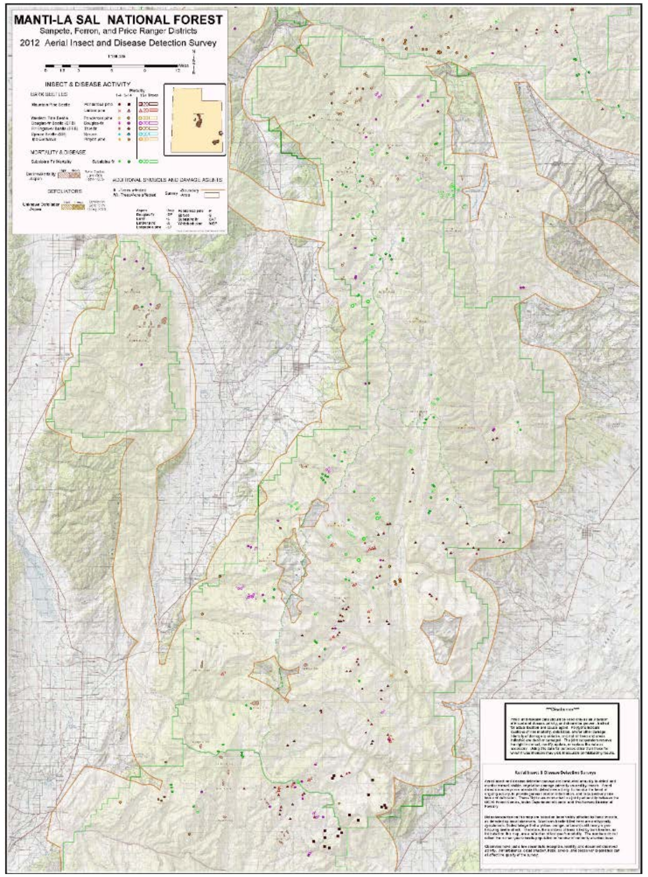
Manti La-Sal National Forest

Photo: A. Steven Munson



Hunter Power Station

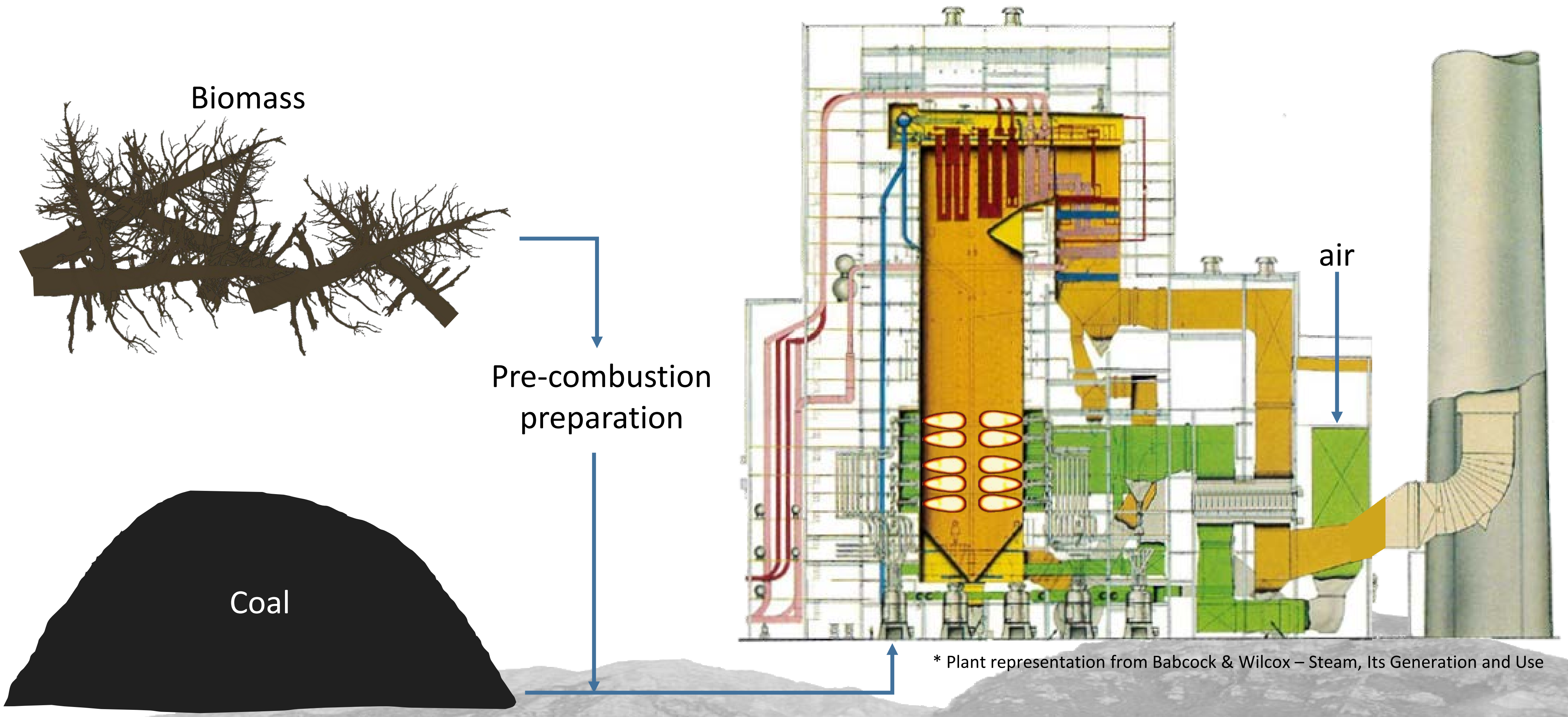
Introduction: Beetle Kill, Manti – La Sal National Forest



Map: US Department of Agriculture

- ~75,000 acres of beetle kill
  - Ponderosa, Douglas-fir, Spruce and Pinyon
- Indicator of unhealthy forest
- Increased potential wildland fires and particulate matter emissions
- Releases greenhouse gases while deadfall decays
  - CO_2 & CH_4

Introduction: Coal / Biomass Co-firing



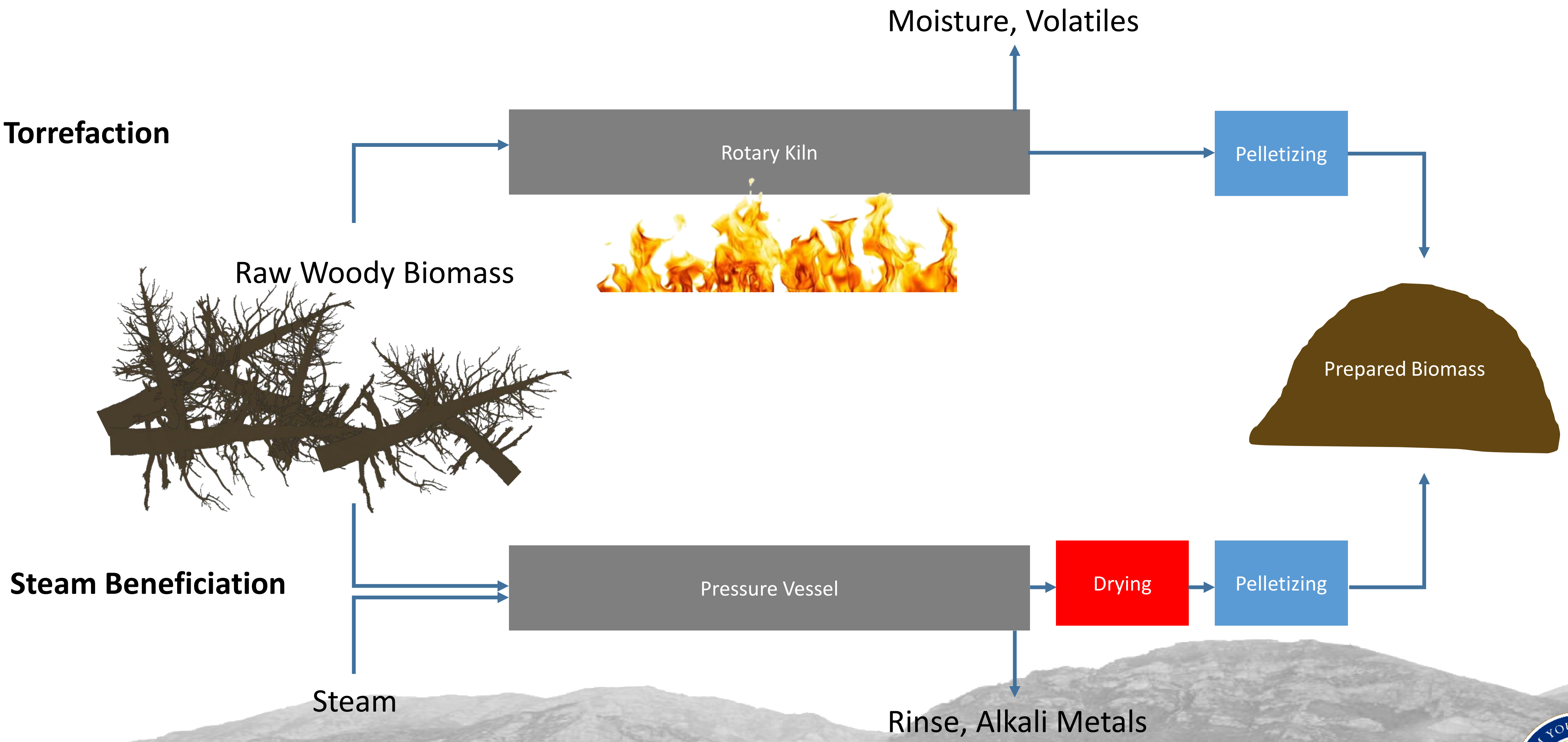
* Plant representation from Babcock & Wilcox – Steam, Its Generation and Use

Introduction: Raw Woody Biomass

- Low energy density
- Too much moisture
- Non-uniform shape = difficult material handling
- Cannot use existing coal handling and milling equipment

We fix these by pre-processing the woody biomass

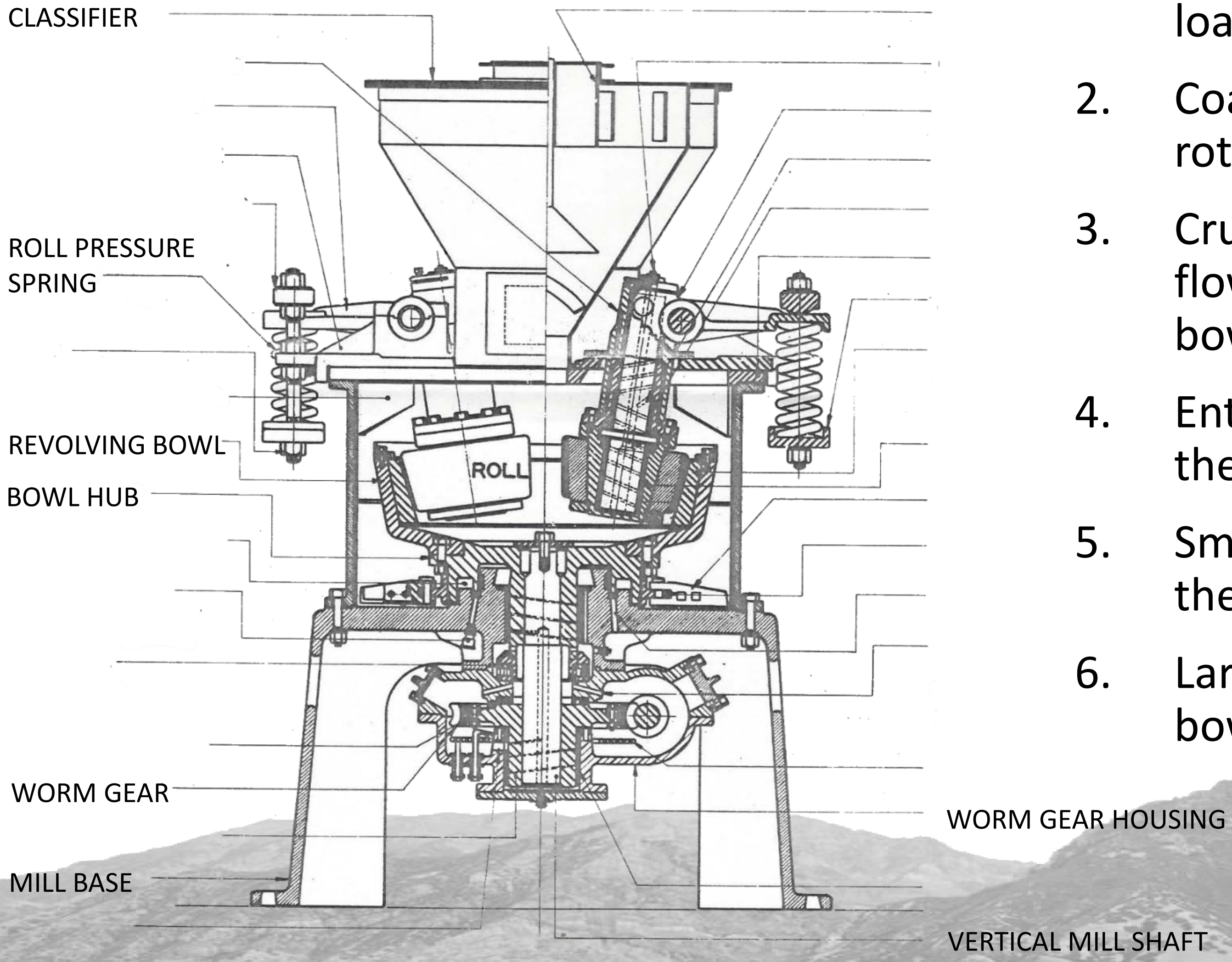
Introduction: Biomass Preparation



Facilities: Mill at the University of Utah

Facilities: Mill Operation

312 Combustion Engineering Raymond Bowl Mill



1. 2” minus coal is continuously loaded into the rotating bowl
2. Coal is crushed between the rotating bowl and the rolls
3. Crushed coal is entrained by air flowing around the outside of the bowl
4. Entrained coal is introduced into the top of the classifier (cyclone)
5. Small particles are carried out of the classifier
6. Large particles are returned to the bowl

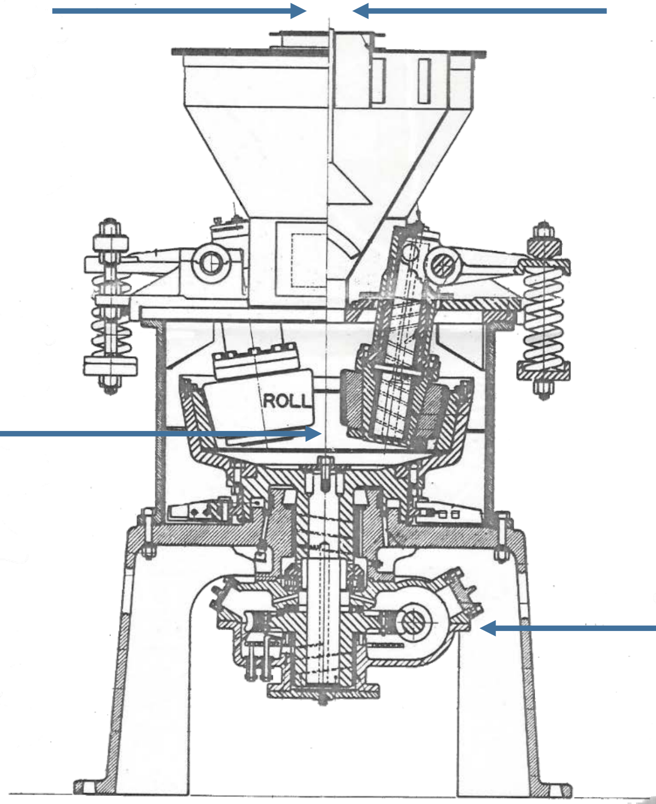
Experimental: Coal and Biomass Properties

		Sufco Coal	Torrefied 210 °C	Torrefied 248 °C	Torrefied 290 °C	Torrefied 325 °C	Steam Beneficiated
Ultimate, As Received (Wt, %)	**Carbon**	61.48	49.41	51.22	55.18	54.98	59.59
	Hydrogen	4.94	6.15	5.85	5.81	5.41	5.81
	Nitrogen	0.91	0.55	0.54	0.59	0.59	0.59
	Sulfur	0.58	BDL	BDL	BDL	BDL	BDL
	Oxygen	15.90	41.21	36.71	35.49	31.59	30.49
	Ash	16.20	2.68	5.67	2.94	7.44	3.52
Proximate (Wt, %)	**Moisture**	4.15	3.43	1.98	0.89	2.24	2.76
	FC	37.6	14.4	15.9	21.9	26	28.6
	VM	42	79.5	76.4	74.3	64.3	65.1
Btu/lb	**HHV**	10551	8924	8871	9494	9703	10246

Experimental: Measurements

Measure the mill exit temperature

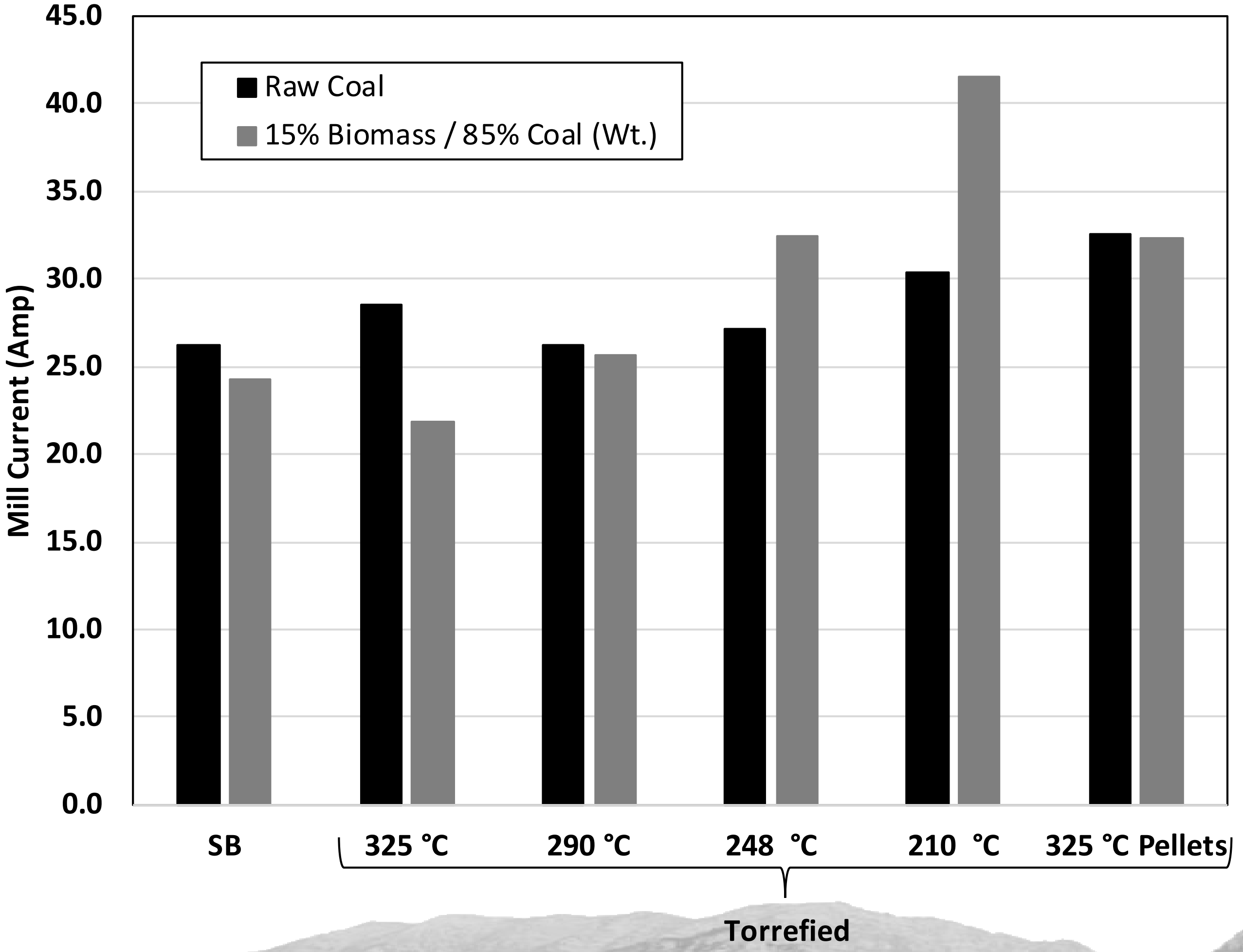
Measure the particle size distribution of the material exiting the mill



Visually inspect the bowl after milling each material

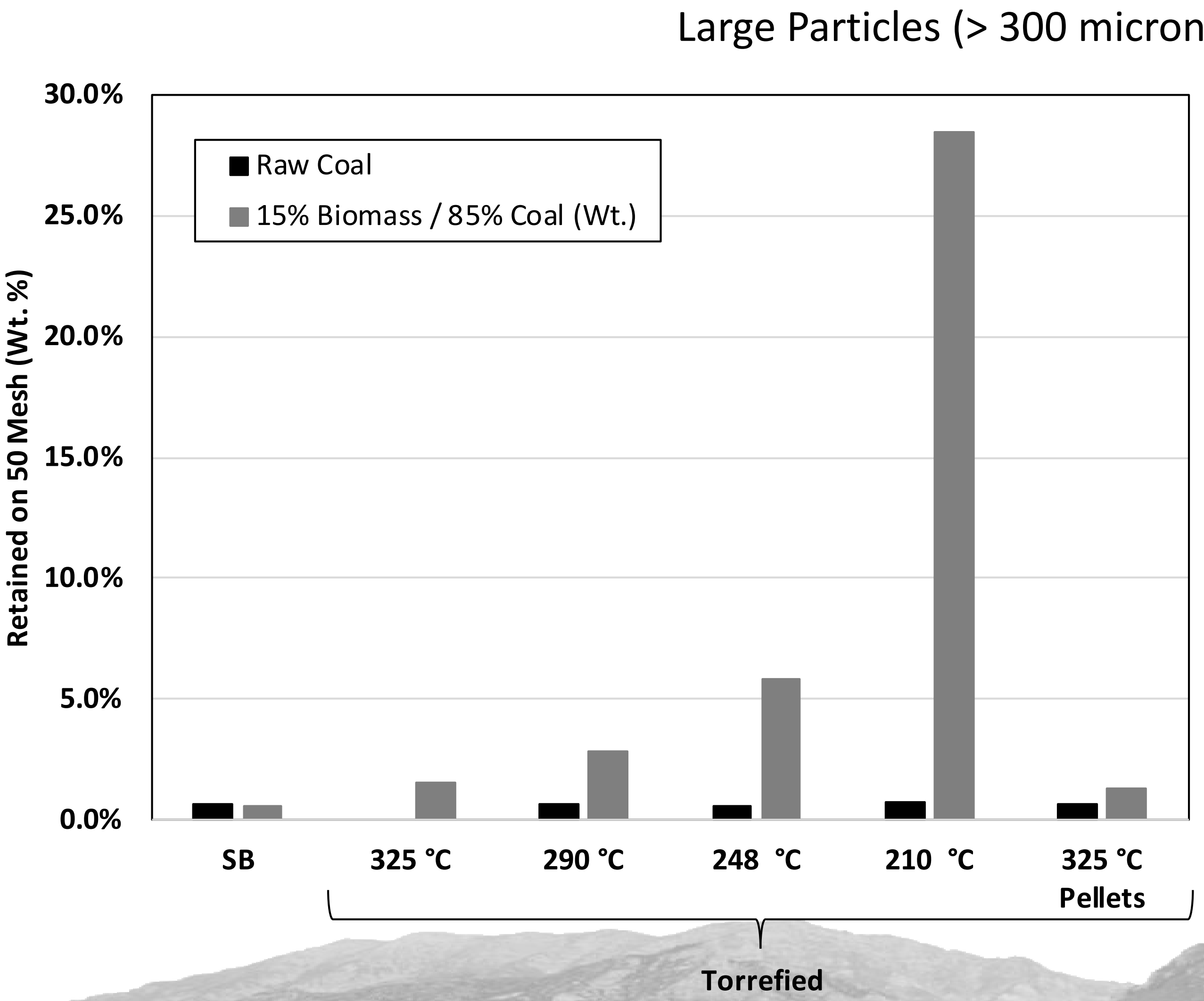
Measure the power requirement of the motor driving the rotating bowl

Results: Mill Current



- Mill current is inversely proportional to the temperature at which biomass is torrefied
  - An indicator of the degree to which the fibrous structure has deteriorated
- Pelletizing increases the power requirement
- 325 °C torrefaction and steam beneficiation both with pelletization do not increase the mill power requirements
- All testing was at approximately the same mass flow rate.

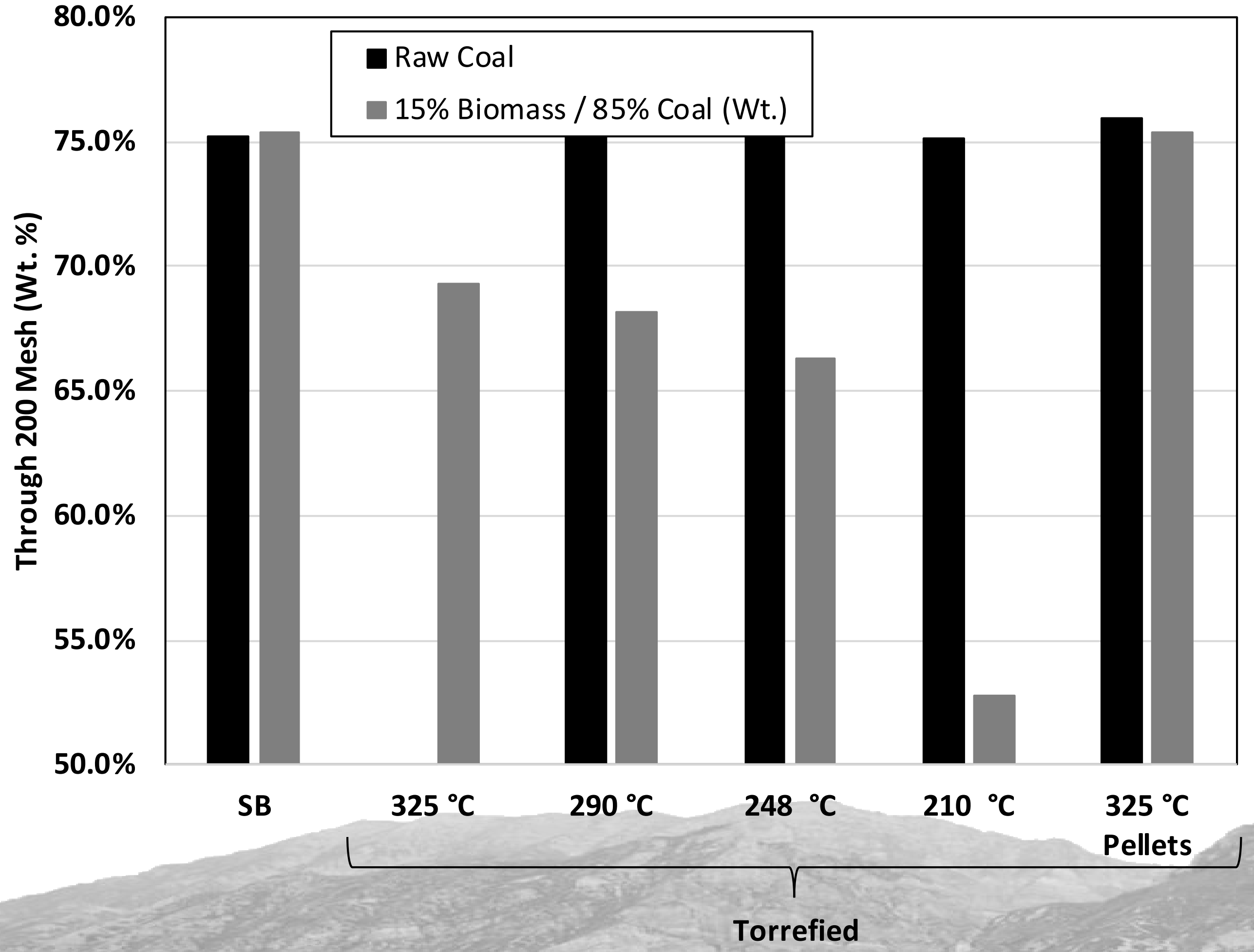
Results: Particle Size



- All torrefied material resulted in an increase in fraction of large particles when compared to pure coal
- Fraction of large particles is reduced from torrified materials when processing temperature is increased
- Large particle effect is minimized with a processing temperature of 325 °C
- Steam beneficiated biomass does not increase the fraction of large particles when compared to pure coal

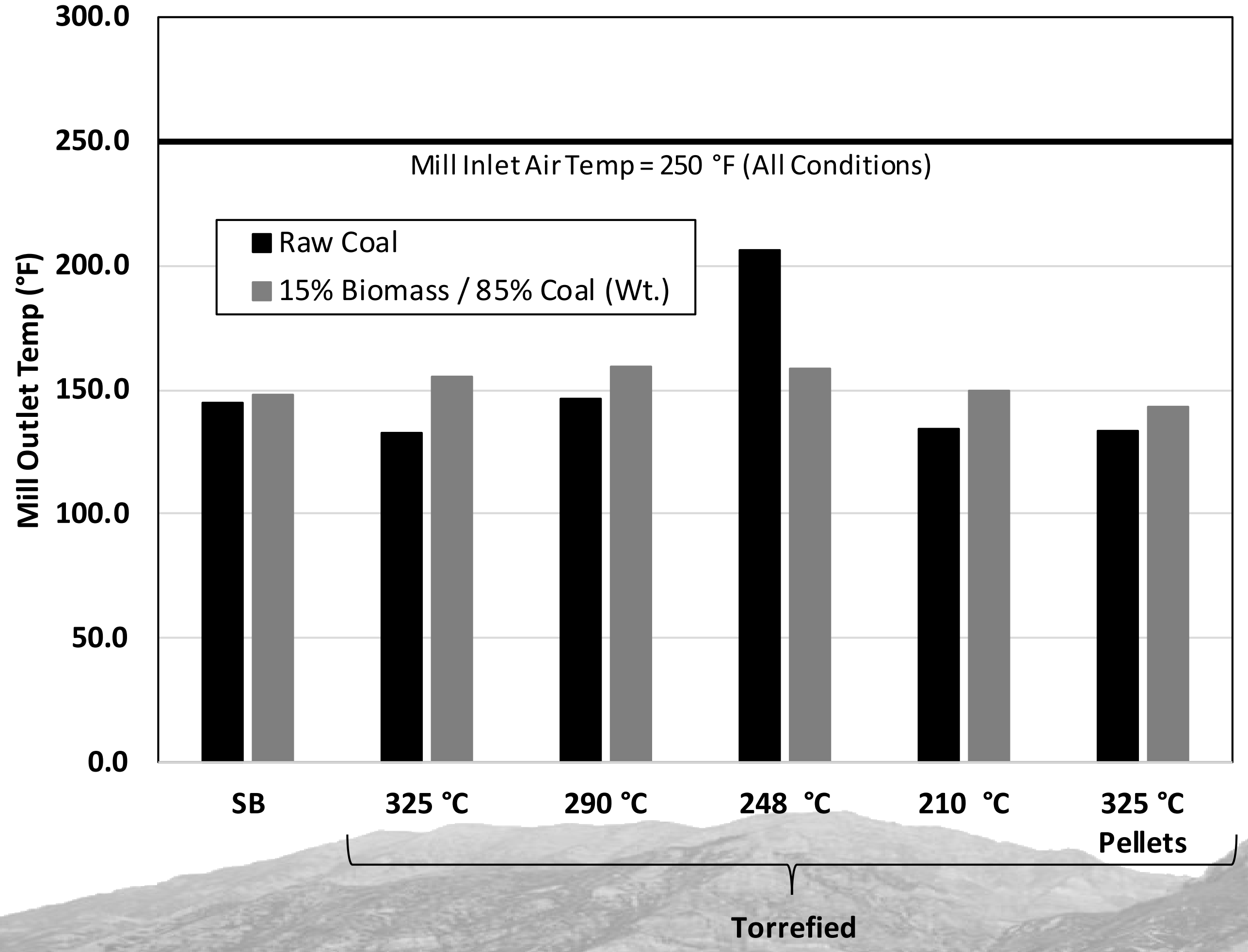
Results: Particle Size

Small Particles (< 70 micron)



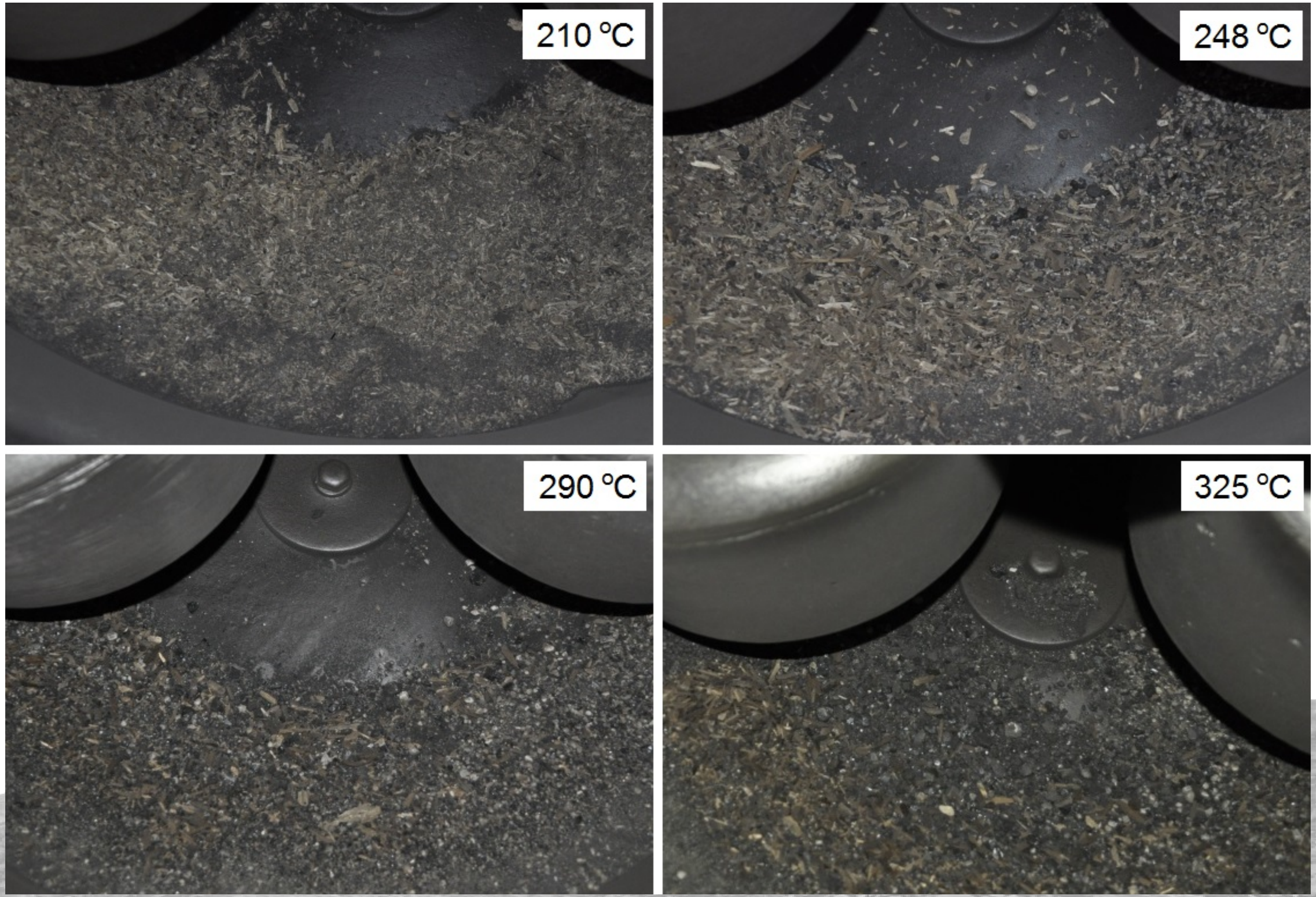
- The requirement of 70% through 200 mesh was achieved by biomass coal blends where the biomass was beneficiated or torrefied at 325 °C and pelletized
- Pelletizing appeared to have an added benefit to the millability of the torrefied material
- Pelletizing needed for long term storage, handling, and to minimize dust

Results: Mill Outlet Temperature



- Mill outlet temperatures were only slightly higher for the coal biomass blends, indicating no unwanted reaction in the mill

Results: Remaining Material in the Bowl
Torrefied



Results: Remaining Material in the Bowl
Steam Beneficiated

Results: Remaining Material in the Bowl
Torrefied and Pelletized

Summary

- Woody biomass was collected that is representative of the beetle kill material in the Manti-La Sal National Forest in Utah
- Woody biomass was prepared for milling tests using a torrefaction process at several torrefaction temperatures and using a steam beneficiation process
- Coal / biomass blends were prepared in an 85% / 15% (mass) mixture with Utah Sufco Coal
- Coal / Biomass lends were milled in a 1 ton per hour CE Raymond Bowl Mill
- The mill power requirement, outlet particle size distribution and outlet temperature were measured and compared to pure coal conditions

Conclusions

- 15% mixtures of both steam beneficiated biomass and torrefied biomass at 325 °C exhibited similar mill power requirements and outlet particle size distributions to the pure coal
- Torrefaction at temperatures below 325 °C resulted in an increase in mill power and an increase in the large particle fraction
- Pelletizing appeared to improve the performance of the torrefied biomass in the mill

Questions