Developing Engineered Fuel (Briquettes)

using Fly-ash from the Aquila coal-fired power plant in Canon City and locally available biomass waste

by

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Objective:

- Produce briquettes with a 50% to 66.67% wood waste and evaluate viability of producing large quantities,
- Test the briquettes produced to flow through Aquila's current system,
- Conduct an economic analysis of a production facility manufacturing such briquettes.

Objective

- Produce 2 tons of briquettes in order to burn them at the plant and observe a definite change in energy available for electricity production,
- Make sure the briquettes are strong enough to withstand the transit to the burners from arrival point at the plant,
- We secured full co-operation from plant management.

Current Situation in SE Colorado

- Fly-ash with usable carbon content can not be currently used.
- Fly-ash is due to the type of dusty coal used and the fact that coal pieces are further crushed on its way to the furnace,
- 45 tons of fly-ash are dumped to landfill daily.
- The area is rich in biomass of all forms.
- Some biomass are used, but most are left to rot or dumped.

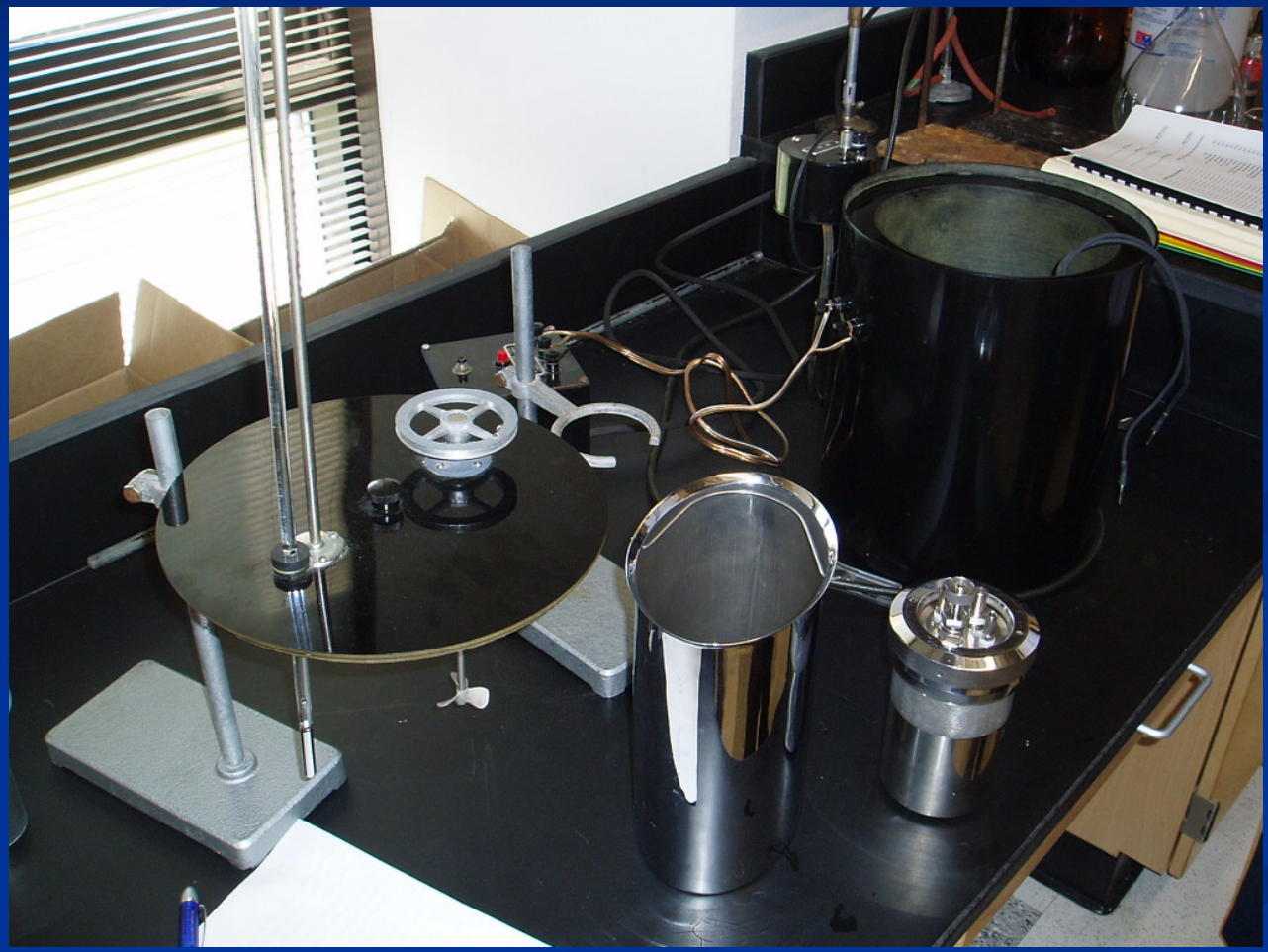
Literature Search

- Research on briquette manufacturers across the world
- Four Plant visits for better understanding of the Process, Machinery and Layout
- Energy analysis and carbon content analysis
- Moisture analysis

Energy Analysis

- Oxygen Bomb Calorimeter was used to determine the total energy in fuel
- Calibration of the Bomb Calorimeter using Benzoic acid
- Sample :Fly Ash from the power plant
- A combustibility problem was observed
- Unburnt wire observed which confirmed the issue

Oxygen Bomb Calorimeter



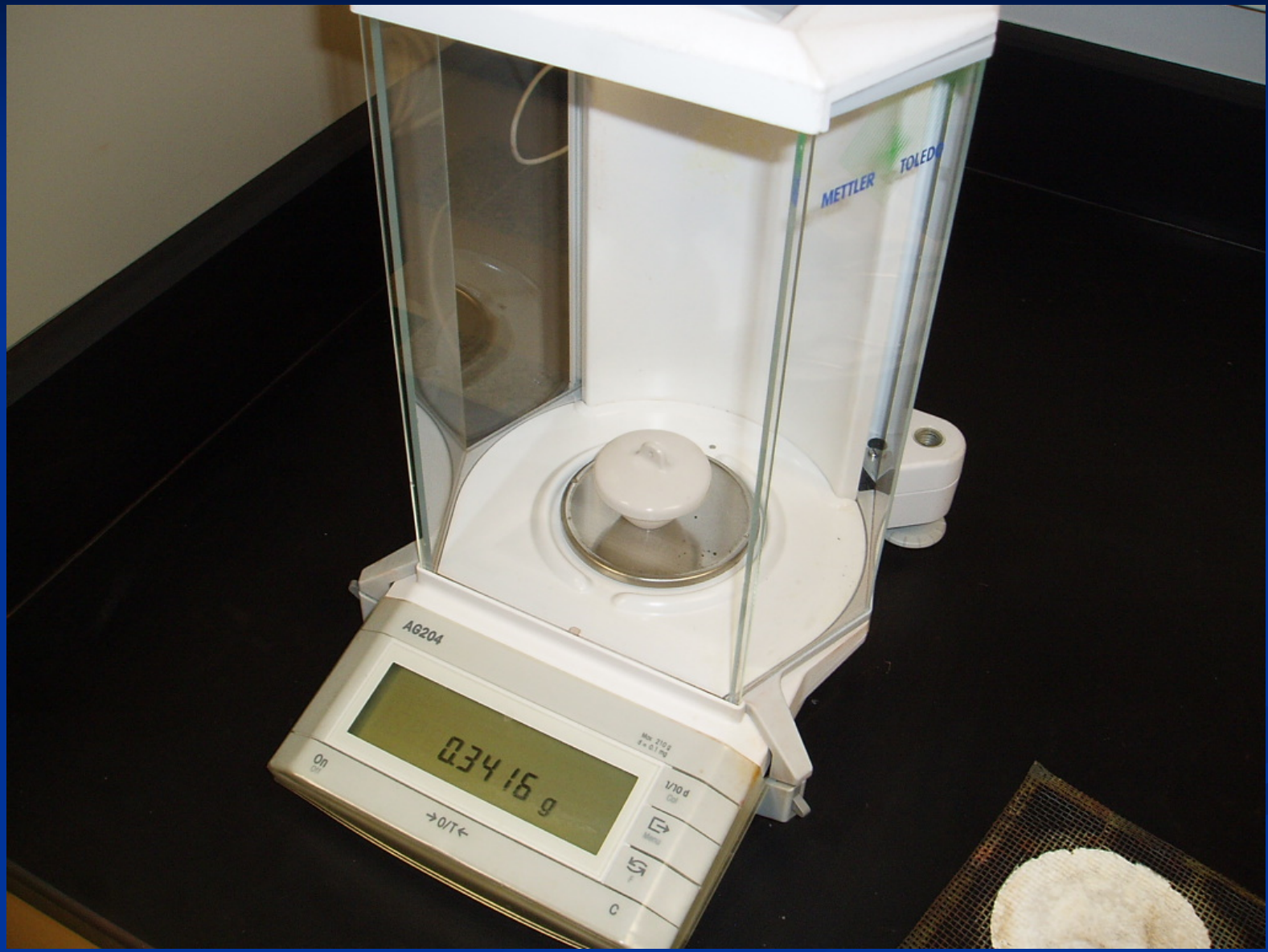
Unburnt Wire samples

Carbon Content Analysis

- The Process used was combustion and mass analysis
- The sample was taken weighed and burnt under standard atmosphere and the residue weighed

Heating sample in flame

Weight measurements



Sample before experiment

Sample after experiment

Pilot Trials

Press

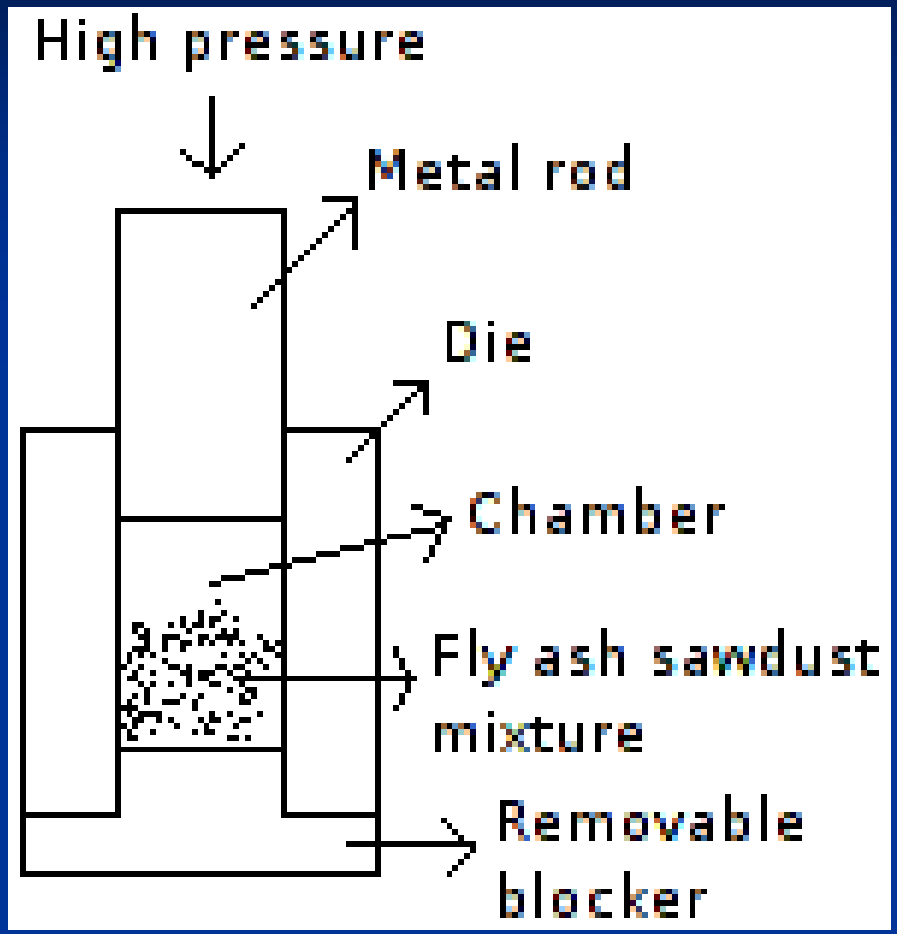
	Sample weight before Combustion	Sample weight after Combustion
First Experiment	0.600g	0.3419g
Second Experiment	0.615g	0.3516g

43% Carbon found in sample

Visit to Aquila Power Plant

Visit to RMF Pellet Manufacturing Plant

Closed Chamber Press Built on Campus



Production steps in pressing process

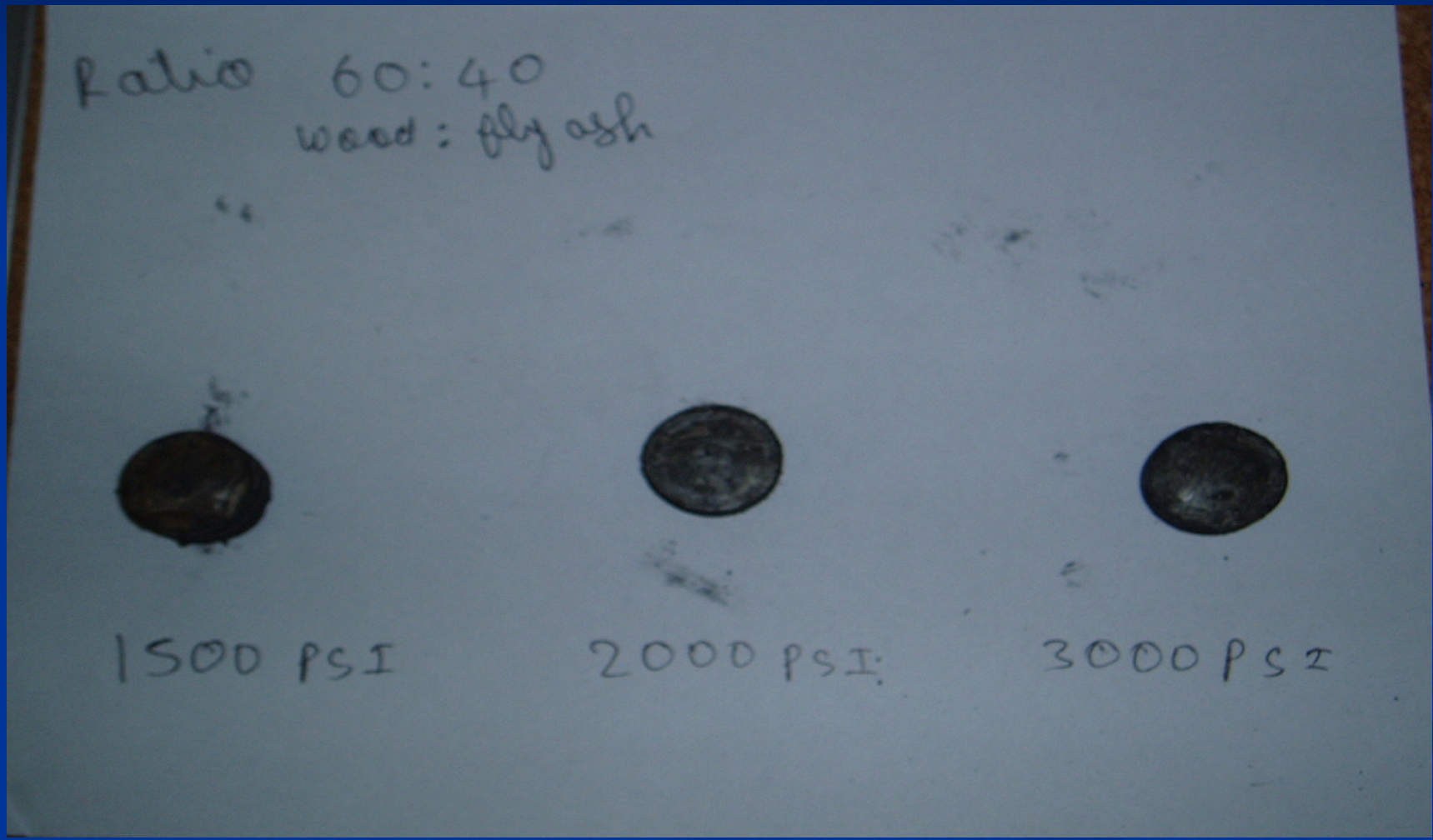
- Dry the sawdust to 6% moisture
- Mix sawdust and fly ash at ratio of (3:2)
- Fill the chamber of die with the mixture
- Apply 3000 Psi Pressure using the lever
- Release pressure and the briquette is produced

Closed Chamber Press

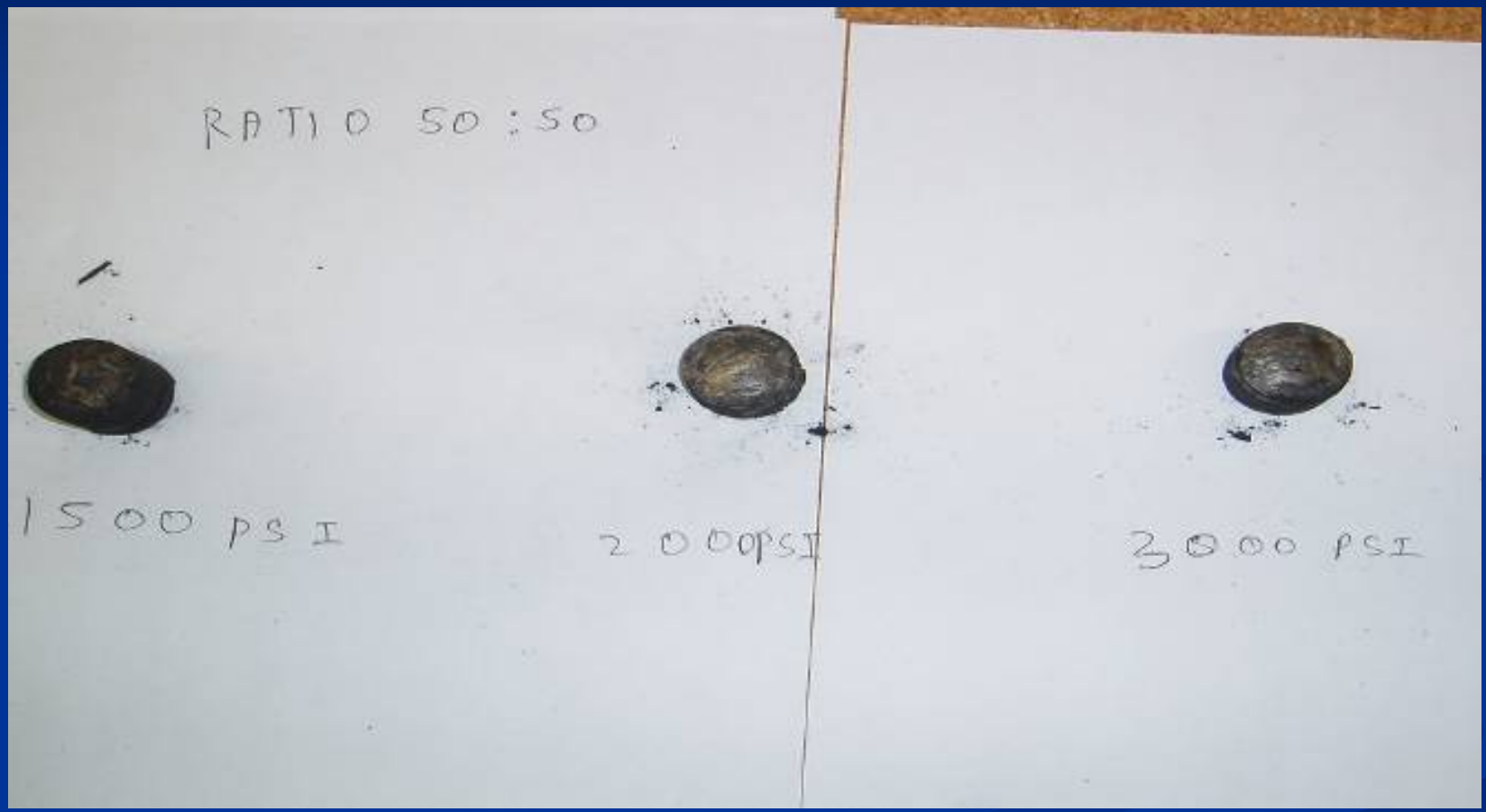
Experiments to determine ideal Briquette

- For various values of pressure
- 1500, 2000 and 3000 psi
- 3000 psi was the ideal pressure
- Several moisture percentage worked with
- 6% was the ideal moisture percentage
- Various ratio of wood and flyash
- Ideal ratio was 60% wood and 40% flyash

Ratio of wood and flyash



Ratio of wood and flyash



Ideal Conditions

- Mix sawdust and fly ash at ratio of 60 :40,
- Pressure value at 3000 PSI,
- Moisture content less than 6%,
- No binder can be used.

Analysis of briquettes

- Energy analysis of the briquette
- Pollution analysis
- Detect presence of other poisonous gases

Result of energy analysis

	First Result		Second Result	
	As Received	Dry	As Received	Dry
% Total Moisture	1.52		2.04	
%Ash	29.02	29.47	22.17	22.63
%Sulphur	0.3	0.31	0.16	0.16
Gross Calorific Value	8372	8601	8309	8482
% Carbon	55.47	56.33	53.2	54.31
%Hydrogen	1.63	1.66	0.27	0.28
%Nitrogen	0.67	0.66	0.67	0.68
%Oxygen	11.37	11.66	21.5	21.94
Fluorine ug/g		98		
% Chlorine	<0.01	<0.01		
Mercury, ug/g		0.31		0.26

Analysis of Briquettes

- Energy analysis of the briquette
- Pollution analysis
- Detect presence of other poisonous gases
- Pressing process was effective but slow
- Hence we went in for extrusion process
- Extrusion model was developed

Initial Action Plan

- Produce enough briquettes using the closed chamber press for testing (energy, strength),
- Build a machine on campus to produce 2 tons of briquettes,
- Ship the briquettes to the power plant as fuel.
- After much deliberation, we realized that a machine with sufficient power and speed could not built within the available time and budget.

Revised Plan/Action

- We began looking for suitable local companies that can process our mixture,
- We visited the La Junta Mill & Elevator Company to study their process of making animal feed using an extrusion process.
- We decided to build a small extrusion model to simulate the operation at the plant.
- The results were satisfactory and the plant management agreed to produce our briquettes at labor cost only.

Extrusion model developed on Campus

Briquettes Produced

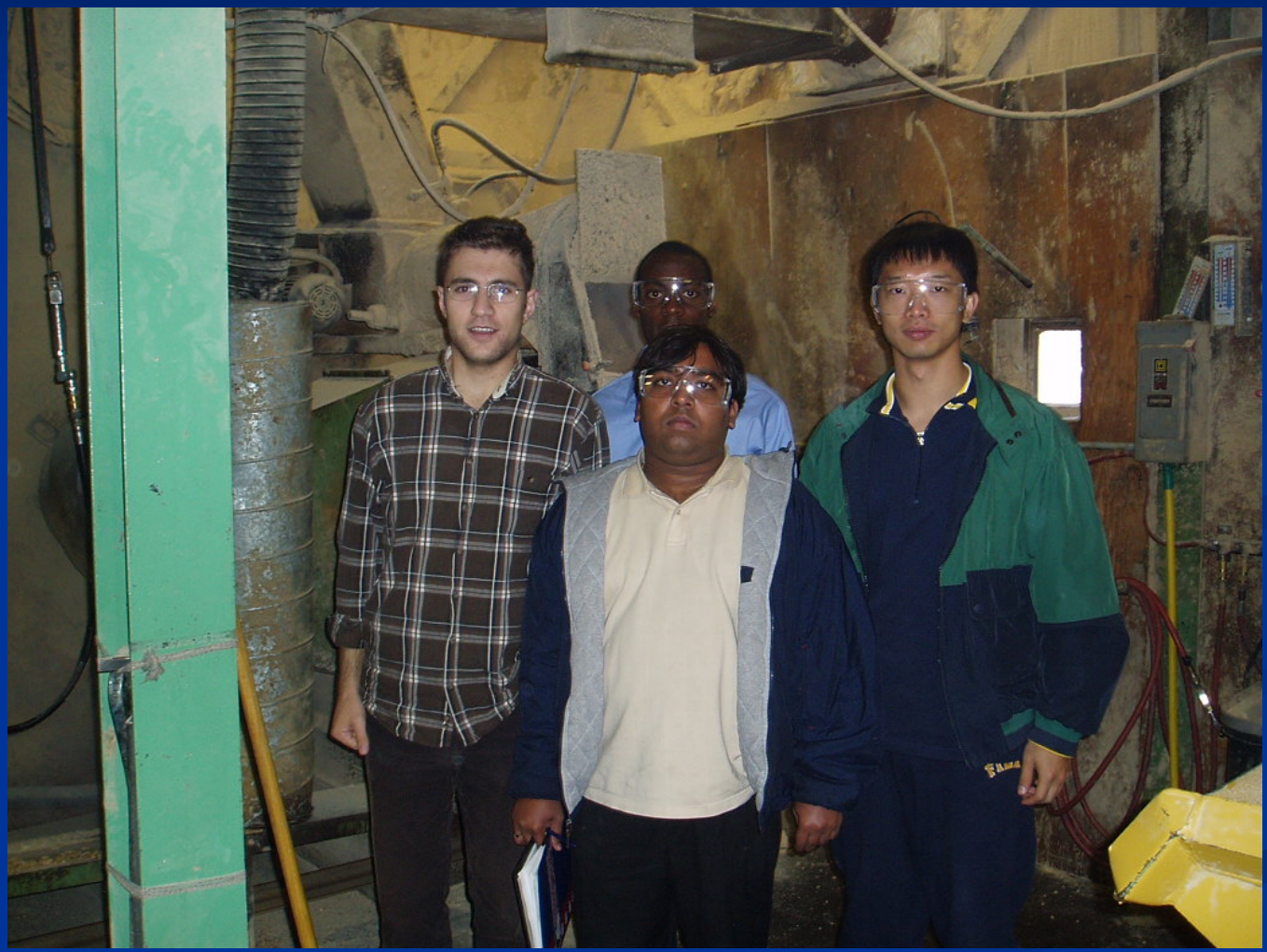
Reason to go to La Junta Mill

- The briquettes produced using the simulation model was satisfactory,
- Good results were obtained when mechanical properties of Briquettes produced using various process was compared.
- It became obvious that we could not produce 2 tons of briquettes in-house.

Comparison of mechanical strength

Parameters of the new briquette produced by Extrusion process			
	Pressure(psi)	Weight(g)	Height(cm)
Sample	Wood Ground,seived and hammered	Wood Ground	Wood Ground,seived and hammered
1	175	12.5	3.5
2	178.2	14	4.2
3	189.2	14.6	4.8
4	184.2	15.1	4.9
5	180.2	15.4	5.6
6	178.6	16.5	6.2
7	168.2	13.8	4.2
8	184.6	15.6	5.3
9	168.3	14.2	4.3
10	184.2	14.7	4.8
11	182.2	15.6	5.5
Minimum	168.2	12.5	3.5
Maximum	189.2	16.5	6.2
Average	179.07	14.64	4.78

Trip to La junta



Goal = 4000 lbs of Briquettes

- 2400 lbs of dried biomass were transported to the mill and hammer milled into finer particles,
- The power company shipped 1600 lbs of flyash,
- 2400 lbs of dried biomass and 1600 lbs of fly-ash were thoroughly mixed at the mill,
- The pellet production machine caught fire early in the production attempt.

Some Problems

- We planned on using actual forest waste, successfully obtained some, dried, and ground it into small particles.
- Grinding became very hard for large quantities and the forest service did not help us much.
- We switched to sawdust from a nearby mill.
- Drying became the biggest problem as we could not locate a commercial grain dryer anywhere.

Failure at La Junta

Failure Analysis at La- Junta

- Due to tapered shape of the holes in their dies the emerging briquettes got stuck, became heated, and combusted.
- The heat produced in the process due to the high speed rollers.
- Process was designed to work with cattle feed **with** binder and these materials are much softer and less abrasive than our materials for briquettes

Economics of the Activity

- Direct savings in fuel and dumping costs should save the plant about $500,000/year.
- It is likely that the overall financial analysis will be favorable once all monetary factors are considered.
- This project showed that the idea is feasible.
- Complete cost analysis is the topic of an ongoing MS thesis.

Summary of Economic Analysis (Fly-ash)

- Energy produced by briquettes will not be produced by coal,
- Renewable energy credits from the briquettes,
- Additional jobs will be created in the community,
- Energy efficiency improvement will be realized at the Aquila plant by using briquettes.

Summary of Economic Analysis (Fly-ash)

- Impact of not sending fly-ash to landfills has significant long term cost avoidance or savings,
- Fly-ash degrades air quality since it is a powder that can fly off with the wind. Reduction or avoidance of this means savings,
- Fly-ash can also degrade water quality through rain taking pollutants in fly ash into the ground. Again, reduction or avoidance of this means savings.

Summary of Economic Analysis (Biomass)

- Emissions reductions from not burning the wood in the forest or letting the wood rot versus burning it as briquette,
- Energy produced and used by making briquettes from wood and not burning the wood in the forest or letting the wood rot,
- Jobs created for bringing the wood to plant versus burning the wood in the forest or letting the wood rot ,
- environmental impact of letting the wood rot in a landfill - any water quality issues?

Conclusion

- Extrusion is a good technique to produce the briquettes,
- Binder would be very helpful in the process,
- Significant cost savings are possible from project
- Further study is really necessary.