Biomass is organic material that contains stored energy from the sun. Biomass can be used instead of fossil fuels for power generation. Bioenergy is currently being studied in the US in order to reduce the nation’s dependence on foreign oil and to reduce carbon dioxide emissions. Currently, wood is the largest biomass energy resource. Unfortunately, during the harvesting and handling of wood, contaminants, ash content from soil becomes attached to the biomass. This ash contains alkali earth metals that poisons catalysts during the thermochemical and biochemical conversion processes. Potassium causes the most adverse effects. Washing the biomass removes the attached potassium which increases the biofuel production efficiency.

**Objectives**

- Design a washing mechanism for the Auburn University Center for Bioenergy and Bioproducts that has a capacity of 2,500 dry pounds per day. The system must remove 90% of attached potassium from Southern Pine wood chips by soaking them for 10 minutes in a sulfuric acid solution where the concentration of sulfuric acid is 18M, the pH is 2, the temperature is 30°C, and the biomass to water ratio is 1:10. The biomass will need to be rinsed with water based on a weight ratio of 1:3.
- Design a process that will dewater the biomass so that the moisture content is within 5% of the original.
- Design a disposal system for all wastewater that meets ADEM standards.
- Design the system to meet OSHA operator safety requirements.

**Site Design**

- 30'x30'x6" steel reinforced concrete slab designed to withstand the 80,000 lb weight of the system.
- Center drain to capture any spills or precipitation.
- 5.2 yd³ of soil removed and 12.5 yd³ of soil filled to create a level surface with a 3:1 slope grading ratio.
- A force main will transport treated wastewater to sanitary sewer, shown in Figure 1.
- The force main is comprised of a 100 gpm pump and 4" ductile iron pipe buried at 36".

**Washing System Design**

1. Auger delivers 118lbs wood chips into metal baskets.
2. Crane transports baskets to washing tank.
3. Sulfuric acid solution is mixed in hydraulic system.
4. Sulfuric acid solution is added to washing tank.
5. Wood chips soak for 10 minutes.
6. Sulfuric acid solution drained to wastewater system.
7. Wood chips are rinsed for one minute.
8. Rinsing water drained to wastewater system.
9. Crane lifts baskets, moisture drains from wood.
10. Wood chips transport baskets to hopper.
11. Wood chips are conveyed into dryer.
12. Dry wood chips are placed in storage.

**Waste Treatment Design**

- The used sulfuric acid washing solution and rinsing water are pumped to a 400 gal storage tank from the wash tanks.
- Wastewater is pumped from the storage tank to the clarifier at a constant 18 gpm. Solids settle in inclined parallel plate clarifier.
- Clarified wastewater exits clarifier and enters mixing tank by gravity.
- Sodium hydroxide is added to mixing tank to neutralize pH.
- Mixing tank is continuously stirred with an impeller.
- Treatment raises pH from 2.1 to 7.0 and lowers BOD from 63 ppm to below 30 ppm. ADEM standards: 6.0≤pH≤8.5  BOD≤30ppm
- Lab analysis confirms clarifier has adequate settling area.

**Cost Analysis**

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th>Monthly Operating Costs</th>
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</thead>
<tbody>
<tr>
<td>Solution Mixing System</td>
<td>$16,161.31</td>
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<tr>
<td>Washing System</td>
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<tr>
<td>Rinsing System</td>
<td>$2,620.81</td>
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<td>Washer Drainage</td>
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<td>Wastewater System</td>
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<td>Forged Main</td>
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<td>Drying System</td>
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<td>Platform</td>
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<td>Concrete Slab</td>
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<td>Contingencies</td>
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<tr>
<td>Total</td>
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</table>

<table>
<thead>
<tr>
<th>Unwashed Wood Chips</th>
<th>Washed Wood Chips</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>$36.27</td>
<td>$111.98</td>
<td>307%</td>
</tr>
</tbody>
</table>

**Summary**

- The washing process increases the efficiency of biofuel production by removing 90% of potassium from wood chips.
- This design provides a semi-continuous flow of washed wood chips.
- Wood is dewatered by crane lifting basket from washer.
- An onsite wastewater treatment system raises the pH and lowers the BOD of the water to comply with ADEM standards.
- The system was designed to remove operators from risk.
- This process increases the cost of wood chips by 307%.

**Acknowledgements**

Special thanks to Dr. Mark Dougherty and Dr. David Blersch