Drying of Woody Biomass

Process Engineering / GEA Barr-Rosin
Drying of Woody Biomass
Conventional Direct Fired Dryer Technology
Issues with conventional dryers

- Fire and Explosion Risks
- Large footprint
- Significant leaks at rotary dryer seals use more energy
- Energy input is lost to atmosphere
- VOC emissions
- Require separate thermal oxidizer for gas clean up
Superheated Steam Rotary Dryer
Superheated Steam Dryer

- Clean LP Steam
- Generated Steam
- Cold-Hot Water or Condensate from another process
- Condensate to Sewer
- Process Air
- Heat Source (Flue Gas)
- Super Heater
- Backmix
- Screw
- Condensate to Sewer
- Exhaust
- Natural Gas
- Air Heater
- Combustion Fan
- Fresh Air
- Mixer
- WET FEED
- DRY PRODUCT
- Proprietary work of the Copyright Owner
Progression of heat recovery options

Open Cycle dryer

Process Gas Recycle Dryer

Superheated Steam Dryer
Partial Gas Recycling

SSD
Rotary Drum

Oxygen/Fuel Heated dryer

SSD
Ring Dryer

Open Circuit Dryer

Dew Point Temperature

kg H2O / kg dry air

0 2 4 6 8 10 12
Boiler SSD Dryer Combination

Proprietary work of the Copyright Owner
Comparisons of burning wet & dry Fuel

Process Engineering / GEA Barr-Rosin
## Typical Biomass Properties

<table>
<thead>
<tr>
<th>Name</th>
<th>Fixed Carbon</th>
<th>Volatiles</th>
<th>Ash</th>
<th>C</th>
<th>H</th>
<th>O</th>
<th>N</th>
<th>S</th>
<th>HHV MEAS</th>
<th>HHV CALC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOOD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beech</td>
<td>-</td>
<td>-</td>
<td>0.65</td>
<td>51.64</td>
<td>6.26</td>
<td>41.45</td>
<td>0.00</td>
<td>0.00</td>
<td>20.38</td>
<td>21.10</td>
</tr>
<tr>
<td>Black Locust</td>
<td>18.26</td>
<td>80.94</td>
<td>0.80</td>
<td>50.73</td>
<td>5.71</td>
<td>41.93</td>
<td>0.57</td>
<td>0.01</td>
<td>19.71</td>
<td>20.12</td>
</tr>
<tr>
<td>Douglas Fir</td>
<td>17.70</td>
<td>81.50</td>
<td>0.60</td>
<td>52.30</td>
<td>6.30</td>
<td>40.50</td>
<td>0.10</td>
<td>0.00</td>
<td>21.05</td>
<td>21.46</td>
</tr>
<tr>
<td>Hickory</td>
<td>-</td>
<td>-</td>
<td>0.73</td>
<td>47.67</td>
<td>6.49</td>
<td>43.11</td>
<td>0.00</td>
<td>0.00</td>
<td>20.17</td>
<td>19.82</td>
</tr>
<tr>
<td>Maple</td>
<td>-</td>
<td>-</td>
<td>1.36</td>
<td>50.64</td>
<td>6.02</td>
<td>41.74</td>
<td>0.26</td>
<td>0.00</td>
<td>19.96</td>
<td>20.42</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>17.17</td>
<td>82.64</td>
<td>0.29</td>
<td>49.25</td>
<td>5.99</td>
<td>44.36</td>
<td>0.06</td>
<td>0.03</td>
<td>20.02</td>
<td>19.66</td>
</tr>
<tr>
<td>Poplar</td>
<td>-</td>
<td>-</td>
<td>0.65</td>
<td>51.64</td>
<td>6.26</td>
<td>41.45</td>
<td>0.00</td>
<td>0.00</td>
<td>20.75</td>
<td>21.10</td>
</tr>
<tr>
<td>Red Alder</td>
<td>12.50</td>
<td>87.10</td>
<td>0.40</td>
<td>49.55</td>
<td>6.06</td>
<td>43.78</td>
<td>0.13</td>
<td>0.07</td>
<td>19.30</td>
<td>19.91</td>
</tr>
<tr>
<td>Redwood</td>
<td>16.10</td>
<td>63.50</td>
<td>0.40</td>
<td>53.50</td>
<td>5.90</td>
<td>40.30</td>
<td>0.10</td>
<td>0.00</td>
<td>21.03</td>
<td>21.45</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td>15.20</td>
<td>64.80</td>
<td>2.20</td>
<td>50.40</td>
<td>5.80</td>
<td>41.10</td>
<td>0.10</td>
<td>0.10</td>
<td>20.05</td>
<td>20.14</td>
</tr>
<tr>
<td>Yellow Pine</td>
<td>-</td>
<td>-</td>
<td>1.31</td>
<td>52.60</td>
<td>7.00</td>
<td>40.10</td>
<td>0.00</td>
<td>0.00</td>
<td>22.30</td>
<td>22.44</td>
</tr>
<tr>
<td>White Fir</td>
<td>16.68</td>
<td>83.17</td>
<td>0.25</td>
<td>49.00</td>
<td>5.98</td>
<td>44.75</td>
<td>0.05</td>
<td>0.01</td>
<td>19.95</td>
<td>19.52</td>
</tr>
<tr>
<td>White Oak</td>
<td>17.20</td>
<td>61.26</td>
<td>1.52</td>
<td>49.48</td>
<td>5.38</td>
<td>43.13</td>
<td>0.35</td>
<td>0.01</td>
<td>19.42</td>
<td>19.12</td>
</tr>
<tr>
<td>Madrone</td>
<td>12.00</td>
<td>87.80</td>
<td>0.20</td>
<td>48.94</td>
<td>6.03</td>
<td>44.75</td>
<td>0.05</td>
<td>0.02</td>
<td>19.51</td>
<td>19.56</td>
</tr>
<tr>
<td>Mango Wood</td>
<td>11.36</td>
<td>65.64</td>
<td>2.98</td>
<td>45.24</td>
<td>6.08</td>
<td>44.42</td>
<td>0.28</td>
<td></td>
<td>19.17</td>
<td>18.65</td>
</tr>
<tr>
<td>BARK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Douglas Fir bark</td>
<td>25.80</td>
<td>73.00</td>
<td>1.20</td>
<td>56.20</td>
<td>5.90</td>
<td>36.70</td>
<td>0.00</td>
<td>0.00</td>
<td>22.10</td>
<td>22.75</td>
</tr>
<tr>
<td>Loblolly Pine bark</td>
<td>33.90</td>
<td>54.70</td>
<td>0.40</td>
<td>56.30</td>
<td>5.60</td>
<td>37.70</td>
<td>0.00</td>
<td>0.00</td>
<td>21.78</td>
<td>22.35</td>
</tr>
<tr>
<td>ENERGY CROPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eucalyptus Camaldulensis</td>
<td>17.82</td>
<td>61.42</td>
<td>0.76</td>
<td>49.00</td>
<td>5.87</td>
<td>43.97</td>
<td>0.30</td>
<td>0.01</td>
<td>19.42</td>
<td>19.46</td>
</tr>
<tr>
<td>Casuarina</td>
<td>19.58</td>
<td>78.52</td>
<td>1.83</td>
<td>48.60</td>
<td>6.04</td>
<td>43.32</td>
<td>0.31</td>
<td>0.00</td>
<td>18.77</td>
<td>19.53</td>
</tr>
<tr>
<td>Poplar</td>
<td>16.35</td>
<td>82.32</td>
<td>1.33</td>
<td>48.45</td>
<td>5.85</td>
<td>43.69</td>
<td>0.47</td>
<td>0.01</td>
<td>19.38</td>
<td>19.26</td>
</tr>
<tr>
<td>Sudan Grass</td>
<td>18.60</td>
<td>72.75</td>
<td>8.65</td>
<td>44.58</td>
<td>5.35</td>
<td>39.18</td>
<td>1.21</td>
<td>0.01</td>
<td>17.39</td>
<td>17.62</td>
</tr>
</tbody>
</table>
Basis for Comparison

Heat available in wet Fuel

1 mJ/kg = 430 btu/lb
### Basis for Comparison

- **Biomass Fuel**: Poplar
- **Calorific Value (HHV)**: 20,750 kJ/kg
- **Feed Moisture**: 50%
- **Combustion air preheat temperature**: 130°C
- **Flue gas exhaust temperature**: 90°C
- **SSD Product Moisture**: 5%
- **Dryer internal pressure**: 4 bara
- **Dryer inlet temperature**: 440°C
- **Dryer outlet temperature**: 130°C
- **Isoentropic efficiency of turbines**: 88%
Biomass Boiler Using Wet Fuel

- Wet Fuel: 40.32 t/hr @ 50% moisture
- Boiler: 100 T/hr
- HP Steam: 70 bar
- Condenser: 0.1 bar
- Combustion Air: 31 mW
- Exhaust: 90°C

Process Engineering / GEA Barr-Rosin
Biomass Boiler with SSD Preheating Feedwater
Biomass Boiler Generating extra power from SSD

Boiler 100 T/hr

Exhaust 90°C

Combustion Air

HP Steam 70 bar

HP Turbine 31 mW

LP Turbine 2.7 mW

Condenser 0.1 bar

Superheater 400 kW

Bleed Off steam

SSD

Wet Fuel 40.32 t/hr @ 50% moisture

Dry Product to Fuel Storage

Pre-dried Fuel

Economiser

Reboiler

Combustion Air

Dry Product

Condensate

400 kW

Economiser

Dirty Condensate

Proprietary work of the Copyright Owner

Process Engineering / GEA Barr-Rosin
Advantages of using Dry Fuel

- Higher net calorific value & efficiency
- Dry fuel is easier to store & meter which gives better combustion control
- Fuel is stable & will not rot in storage
- Less CO2 emissions
- Low Humidity exhaust & lower acid dew point
- Smaller gas cleaning systems
- Lower exhaust volume
- Less visible plume
- If wet sludges are produced on site dryer gives a consistent fuel
Flexible Fuel solution can burn multiple fuels

- Any organic waste material
- Fibre or Bran
- Sawdust
- Waste wood
- Straw
- Lignin
- Dried sludges municipal & Industrial
- Biogas or waste liquid fuel via auxiliary burner
Dryer for Softwood waste Northern Sweden

SSD Dryer, Skellefteå Kraft, Northern Sweden for Wood Chips & Sawdust
22 ton evaporation/hour
Product for Wood Pellets
Recovered steam to Power & District heating

<table>
<thead>
<tr>
<th>Inlet</th>
<th>% DS</th>
<th>t/h</th>
<th>C</th>
<th>bar</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>50</td>
<td>50</td>
<td>10</td>
<td>-</td>
<td>395</td>
</tr>
<tr>
<td>Heating steam latent</td>
<td>-</td>
<td>(33)</td>
<td>250</td>
<td>25</td>
<td>17540</td>
</tr>
<tr>
<td>Electrical power</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1000</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>18935</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outlet</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>90</td>
<td>22.8</td>
<td>100</td>
<td></td>
<td>1235</td>
</tr>
<tr>
<td>Generated steam</td>
<td>-</td>
<td>27</td>
<td>145</td>
<td>4.2</td>
<td>17500</td>
</tr>
<tr>
<td>Heat losses</td>
<td>0.2</td>
<td>100</td>
<td>-</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>18935</td>
</tr>
</tbody>
</table>
Dryer for Wood Waste Denmark

SSD Dryer, for Energi E2
Located at Jünkers flooring plant
in Köge, Denmark
for wood pellet production shipped to
Avedore Power Plant
20 tons/hr evaporation
Recovered steam to drying & curing
ovens for flooring
Dryer for Sawdust

Super-heated Steam Dryer, Techwood BV, Netherlands
Sawdust for composite profiles, 2 ton/h
From 85% up to >99% dryness