IEA – Workshop Copenhagen
Small scale biomass co-generation
with modern steam engines

Dipl.-Ing. Till Augustin
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Solid Biomass Cogeneration with Spilling Steam Engines

Contents:

- Who is Spilling
- Heat and Power from Biomass Steam Power Plants
- The Spilling Steam Engine
- Examples
Spilling: Company Information

- Engine and Turbine Manufacturer
- Location: Hamburg
- Founded in 1889
- Product Lines:
  - Steam Engines
  - Steam Turbines
  - Gas Expanders
Spilling's Program: Decentralized Co-Gen Equipment
Biomass Steam Cogeneration
Optimal Use of Energy with CHP

~10 - 25% Boiler Losses

100% Fuel Energy

~70 - 85% Energy Utilization

~5 – 19% Power

~60 - 80% Heat Utilization

Other Losses

Sankey Diagram of Biomass Steam CHP-Plant
### Optimal Use of Energy with CHP

#### Examples for Energy Balances: Biomass Steam Cogeneration Plants

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Multi Stage</td>
<td>Turbine</td>
<td>Solid Biomass</td>
<td>30,0</td>
<td>782</td>
<td>23,460</td>
<td>0,88</td>
<td>26.659</td>
<td>420</td>
<td>60,0</td>
<td>dry sat.</td>
<td>4.830</td>
<td>18,000</td>
<td>18,1%</td>
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<tr>
<td>2</td>
<td>Single Stage</td>
<td>Engine</td>
<td>Solid Biomass</td>
<td>24,0</td>
<td>649</td>
<td>15,576</td>
<td>0,88</td>
<td>17,700</td>
<td>60,0</td>
<td>60,0</td>
<td>dry sat.</td>
<td>1,000</td>
<td>13,500</td>
<td>5,6%</td>
</tr>
<tr>
<td>3</td>
<td>Double Stage</td>
<td>Engine</td>
<td>Solid Biomass</td>
<td>4,0</td>
<td>685</td>
<td>2,740</td>
<td>0,84</td>
<td>3.262</td>
<td>25,0</td>
<td>11,0</td>
<td>dry sat.</td>
<td>333</td>
<td>2,330</td>
<td>10,2%</td>
</tr>
</tbody>
</table>

**Electricity as valuable by-product**
Pure Electricity Production

~10 - 25 % Boiler Losses

100 % Fuel Energy

~ 70 - 80 % Energy into Steam

15 – 25 (30) % Power

~ 55 - 65 % Heat Loss Condenser

Other Losses

Sankey Diagram of Biomass Condensing Steam Power Plant
### Example for Vacuum Condensing Power Generation

#### Examples for Energy Balances: Biomass Steam Power Generation

<table>
<thead>
<tr>
<th>Case</th>
<th>1</th>
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</thead>
<tbody>
<tr>
<td>Primemover</td>
<td>Turbine</td>
</tr>
<tr>
<td>Design / Type</td>
<td>Multi Stage</td>
</tr>
<tr>
<td>Steam Pressure Boiler Outlet [bar abs.]</td>
<td>42</td>
</tr>
<tr>
<td>Steam Temperature Boiler Outlet [°C]</td>
<td>425</td>
</tr>
<tr>
<td>Fuel</td>
<td>solid biomass</td>
</tr>
<tr>
<td>Steam Procution [t/h]</td>
<td>30,0</td>
</tr>
<tr>
<td>Specific Heat Demand for Steam Production [kWh/t]</td>
<td>782</td>
</tr>
<tr>
<td>Steam Heat Capacity Boiler [kW]</td>
<td>23,460</td>
</tr>
<tr>
<td>Boiler Efficiency</td>
<td>0,88</td>
</tr>
<tr>
<td>Firing Capacity Boiler [kW]</td>
<td>26,659</td>
</tr>
<tr>
<td>Inlet Engine / Turbine [bar abs.]</td>
<td>40,0</td>
</tr>
<tr>
<td>Inlet Engine / Turbine °C</td>
<td>420</td>
</tr>
<tr>
<td>Outlet Engine / Turbine [bar abs.]</td>
<td>0,1</td>
</tr>
<tr>
<td>Output at Generator Terminals [kWe]</td>
<td>6,700</td>
</tr>
<tr>
<td>El. Efficiency (gross) related to fuel input</td>
<td>25,1%</td>
</tr>
<tr>
<td>Exhaust Steam Temperature [°C]</td>
<td>46</td>
</tr>
<tr>
<td>Exhaust Steam Utilization</td>
<td>none</td>
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</table>
The Spilling Steam Engine: Modular Design
The Spilling Steam Engine

Design Features:

- modular design
- (from 1 to 6 cylinders; 15 different piston diameters)
- volumetric flow control: filling regulation
- oil free steam
- skid mounted engine set for flexible installation
The Spilling Steam Engine

Key Figures and Facts

- **Power Output**: up to ~ 1.200 kW
- **Steam Flow Rates**: up to ~ 40 t/h
- **Live Steam Pressures**: ~ 6 to 60 bar
- **Back Pressures**: up to ~ 15 bar
Spilling Steam Engine
Spilling Steam Engines: High Part Load Performance

![Graph showing Throughput vs. Capacity and Spec. Steam consumption]

Spilling Energie Systeme GmbH
Spilling Steam Engines:
Example 4 t/h

<table>
<thead>
<tr>
<th>Engine Type:</th>
<th>1/1-H12 TS</th>
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<tbody>
<tr>
<td>Number of Expansion Stages:</td>
<td>2</td>
</tr>
<tr>
<td>Number of Cylinders:</td>
<td>2</td>
</tr>
<tr>
<td>Speed:</td>
<td>[rpm] 1000</td>
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<tr>
<td>Generator Rating:</td>
<td>[kVA] 420</td>
</tr>
<tr>
<td>Voltage:</td>
<td>[V] 400</td>
</tr>
<tr>
<td>Frequency:</td>
<td>[Hz] 50</td>
</tr>
<tr>
<td>Boiler (Exit):</td>
<td>[barg] / [°C] 25.0/265</td>
</tr>
<tr>
<td>Inlet - Engine:</td>
<td>[barg] / [°C] 24.0/260</td>
</tr>
<tr>
<td>Outlet - Engine:</td>
<td>[barg] 0.5</td>
</tr>
</tbody>
</table>

Steam Engine Set Name: Au

Project: Example IEA - Workshop
Steam Engine Set

Chart: DA 14056
Name: Au
Date: 4.10.10
Spilling Engine: Characteristics / Advantages:

- wide operation range
- high (partload) efficiencies
- good regulation behaviour at fluctuating live steam cond.
- good capability for saturated steam
- moderate requirements for boiler feed water treatment
- maintenance by local staff / technicians possible
Comparision of Output Regulation Principles

- Filling Regulation (Engine)
- Nozzle Group Valve Control (T.)
- Throttle Valve Control (Turbine)
Example 1

Bio Sludge Incineration Plant (Netherlands)

Exhaust Steam Utilization for Boiler Feed Water Preheating and Space Heating

El. Output: 514 kWel
Live Steam Data: 11 t/h / 8 bar / Saturated
Steam Outlet Pressure: 0.5 barg
Example 2

Wood Industry
Wood Residues Fired
Boiler Plant
(Austria)

Exhaust Steam Utilization for Process
and Drying Kilns

El. Output: 2 x 1.000 kWel
Live Steam Data: 2 x 24 t/h / 60 bar / Saturated
Steam Outlet Pressure: 11 barg
Example 3

Remote Power Generation for Saw Mill (Congo) with Wood fired Steam Boiler

El. Output: 700 kWel
Live Steam Data: 9 t/h / 25 bar / 250 °C
Steam Outlet Pressure: 0.5 barg
Example 4

Power Generation in a Saw Mill (Australia) with Wood Fired Steam Boiler

El. Output: 425 kWel
Live Steam Data: 5,5 t/h / 34 bar / dry sat.
Steam Outlet Pressure: 1,0 barg

Spilling Energie Systeme GmbH
Spilling Steam Engines suit perfect in small scale co-generation applications with ...

- typical output range from 100 to 1,000 kWel
- fluctuating live steam conditions
- variable steam flow rates
- moderate live steam parameters
Thank you very much for your attention!