Retrofit controlling units and modern draught stabilizers for stoves

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Project ERA-NET Bioenergy “WoodStoves 2020”
Place, Date: Stockholm, 13th Jun 2017
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- Combustion controllers / draught stabilizers used
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  - Emissions
  - Efficiency / prevention of standing losses
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Methodology

- Testing cycle: 8 successive batches (5 full load, 3 part load) including ignition batch.
- Each combustion controller as well as the reference measurements (without controller) has been tested for 3 complete heating cycles (5 full load 3 part load batches).
- Heating losses have been measured after each heating cycle until the flue gas temperature has been cooled down to 50°C.
- Evaluation of emissions based on volume flow and fuel consumption (converted) in mg/MJ.
- For each controller and reference measurement one cycle out of 3 successive batches has been measured (without PM) including the cool down phase.
- Air valve settings:
  - Without controller and for draught stabilizer: Batch 1-2 primary + secondary air open, batch 3-5 primary air closed, secondary air closed by 30%, batch 7-8 secondary air closed by 50%
  - With controller: Batch 1-2 primary + secondary air open, batch 3-8 primary air closed, secondary air open
**Overview on the combustion controllers used**

<table>
<thead>
<tr>
<th>Testing conditions</th>
<th>Controlled draught</th>
<th>Natural draught</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>TATAREK RT8OS-G-TD</td>
<td>Schmid SMR</td>
</tr>
<tr>
<td><strong>Function principle</strong></td>
<td>Thermocouple + electronical flap</td>
<td>Thermocouple + electronical flap</td>
</tr>
<tr>
<td><strong>Placed at</strong></td>
<td>Air supply soaked</td>
<td>Air supply soaked</td>
</tr>
<tr>
<td><strong>Approx. end costumer price incl. accessories</strong></td>
<td>276 €</td>
<td>1,100 €</td>
</tr>
</tbody>
</table>
Free cross section: 6.2 cm²
8 % of the cross section of the pipe
TATAREK RT8OS-G-TD: Parameter adjustment

Combustion curve with marked control parameters

TATAREK RT8OS-G-TD: Parameter optimization (burn-off-curves of batch 4)

Influence of parameter Temp. F8 max resp. min
→ Refilling signal closer at flame extinction
→ Less CO emissions during charcoal burnout

Influence of parameter F4+F5+F6 (Temp + Damper)
→ Less CO and OGC emissions during ignition phase after refilling due to restricted air supply
Air flap is closing completely
The controller has various deposited burn-off-curves which are selected by choosing the stove type per „questionnaire“.

The end user can only adjust two temperatures:
- Glowing-phase-temperature
- Cool-down-temperature

The burn-off-curve has been chosen in agreement with the manufacturer (Schmid), the glowing phase (335°C) and cool down temperature (280°C) was set after some pretests. The thermocouple showed an offset of 20°C.
K+W Compact

Holes covered with air tight tape

Free cross section: 9 cm² 8% of the pipe
### K+W Compact: Parameter adjustment

<table>
<thead>
<tr>
<th>Turn-switch position</th>
<th>Curve</th>
<th>Maximum temperature</th>
<th>Cooldown temperature</th>
<th>Glowing phase temperature</th>
<th>Heat system</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Type A</td>
<td>800 °C</td>
<td>220 °C</td>
<td>300 °C</td>
<td>log wood stove</td>
</tr>
<tr>
<td>1</td>
<td>Type A</td>
<td>800 °C</td>
<td>210 °C</td>
<td>290 °C</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Type A</td>
<td>800 °C</td>
<td>200 °C</td>
<td>280 °C</td>
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</tr>
<tr>
<td>3</td>
<td>Type A</td>
<td>800 °C</td>
<td>190 °C</td>
<td>270 °C</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Type B</td>
<td>800 °C</td>
<td>180 °C</td>
<td>260 °C</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Type B</td>
<td>800 °C</td>
<td>170 °C</td>
<td>250 °C</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Type B</td>
<td>800 °C</td>
<td>160 °C</td>
<td>240 °C</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Type B</td>
<td>800 °C</td>
<td>150 °C</td>
<td>230 °C</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Type C</td>
<td>800 °C</td>
<td>140 °C</td>
<td>220 °C</td>
<td>tiled stove</td>
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<tr>
<td>9</td>
<td>Type C</td>
<td>800 °C</td>
<td>130 °C</td>
<td>210 °C</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Type C</td>
<td>800 °C</td>
<td>120 °C</td>
<td>200 °C</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Type C</td>
<td>800 °C</td>
<td>110 °C</td>
<td>190 °C</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Type D</td>
<td>800 °C</td>
<td>100 °C</td>
<td>180 °C</td>
<td>slow heat release</td>
</tr>
<tr>
<td>D</td>
<td>Type D</td>
<td>800 °C</td>
<td>90 °C</td>
<td>170 °C</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Type D</td>
<td>800 °C</td>
<td>80 °C</td>
<td>160 °C</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Type D</td>
<td>800 °C</td>
<td>70 °C</td>
<td>150 °C</td>
<td></td>
</tr>
</tbody>
</table>

Sorce: User Manual K+W Compact

3 complete testing cycles has been executed with the flap in delivery status
1 testing cycle with the flap where the holes were covered with tape
ATEC Florian: Parameter adjustment

3 cycles have been executed on power level 1 („intelligent“ automatic mode)
Where the draught is regulated automatically
The fan was only used in the first 3 min of the ignition batch.
K+W draught stabilizer

Test stand and position of measurement points

Velocity measurement at the draught stabilizer

Connection to the chimney
Comparison all controllers (Batch 1-8):
Gaseous emissions

control draught

natural draught

Mean (min \( \text{max} \)) n=3

<table>
<thead>
<tr>
<th>Controllers</th>
<th>Gaseous emissions</th>
<th>Lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>operated</td>
<td>OGC</td>
<td></td>
</tr>
<tr>
<td>TATAREC 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schmid SMR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K+W holes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>natural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>draught</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>draught</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stabilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATEC Florian</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.653
723
764
994
1.050
1.454
915
112
70
86
95
85
100
62
0
400
800
1.200
2.000
mg/MJ

Gaseous emissions

Lambda
Comparison all controllers (Batch 1-8):
Particle emissions

controlled draught  natural draught

Mean $\left(\text{min}^{\text{max}}\right)$ n=3

PM

Manual operated
TATAREC 3  Schmid SMR  K+W holes
Manual natural draught  Manual draught stabilizer  ATEC Florian

Best practice operation by expert staff at the test stand!
Optimally air adjustment through pretesting!
Efficiency evaluation

\[ \eta = 100 - q_a - q_b - q_r - q_{\text{cool}} \]

\[ q_{\text{cool}} = \frac{\text{Heat losses}}{\text{Energy of fuel used}} \]

\[ q_r = \frac{\text{Energy of charcoal}}{\text{Energy of fuel used}} \]

100 %

0.5 % accord. DIN EN 13240
Comparison all controllers (Batch 1-8)

controlled draught

natural draught

<table>
<thead>
<tr>
<th>Controller</th>
<th>Efficiency</th>
<th>q_a</th>
<th>q_b</th>
<th>q_cool</th>
<th>q_residue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>61.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TATAREK 3</td>
<td>66.1</td>
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<td></td>
<td></td>
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<tr>
<td>Schmid SMR</td>
<td>66.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K+W Compact holes</td>
<td>63.0</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref</td>
<td>49.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draught regulator open</td>
<td>59.1</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ATEC Florian</td>
<td>55.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notations:
- Efficiency
- q_a
- q_b
- q_cool
- q_residue

Ref: regulated draught open
TATAREK 3: draught regulator open
Schmid SMR: open
K+W Compact holes: draught regulator open

Efficiency values are given in percentage.
Prevention of „hot standing losses“
After 3 batches during the cool-down-phase

Additional to that the prevention of „cold standing losses“ when the stove is not operated has to be charged. This could be **approx. 32 – 54 kWh/month** for a 8 kW stove during the heating season (see presentation on standing losses).
Amortization Schmid SMR at actually log wood prices

With a end customer price of currently approx. 1,100 € and a annual saving of approx. 48 €/a at 100 heating cycles/a results in a payback period of round about 23 years. If the flap of the TATAREK controller which costs about 276 € will be tight, a payback period of approx. 6 years is feasible.
Final conclusions for retrofit controllers

- Reduction of gaseous emissions and increase of efficiency.

- No benefits for particle emissions can be claimed to the automated control units.

- Particle emissions could possibly be reduced by further technical improvement (air adjustment in the beginning of the batch, timing of refilling signal \( \rightarrow \) compromise gaseous vs. particle emissions).

- Distribution and installation (parameter adjustment) of retrofit controllers should be executed only by stove manufacturer or expert staff.

- Biggest advantages of retrofit controllers:
  - Prevention of heat- and standing losses
  - Reduction of maloperation by the user (air adjustment)

- Air tight flaps are highly recommended (safety issues / admission ETA).
Many thanks for listening!

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K+W Compact: Testing results (Batch 1-8)

**Manual operation open**

- 61.5%
- 32.4%
- 1.7%
- 4.1%
- 0.4%

**K+W holes**

- 63%
- 30.5%
- 1.3%
- 4.4%
- 0.8%

**Manual operation closed**

- 64.7%
- 30.4%
- 1.7%
- 2.3%
- 0.9%

**K+W covered**

- 67.2%
- 29.1%
- 1%
- 1.8%
- 1.1%
European Technical Assessment

List of Technical Assessment Body’s:
https://www.eota.eu/en-GB/content/how-to-find-a-tab/55/

Source: https://www.dibt.de/en/dibt/data/ETA_brochure.pdf