Development of Next Generation and Clean Wood Stoves bioenergy crop for Europe WOODSTOVES 2020

Coordinator:
Technology and Support Centre of Renewable Raw Materials (TFZ)

Partners:

- RIKA Innovative Ofentechnik GmbH (RIKA)
- BIOS BIOENERGIESYSTEME GmbH (BIOS)
- Kutzner + Weber GmbH
- RISE Research Institutes of Sweden (formerly SP)
- Nibe AB
- Technical University of Denmark (DTU)
- HWAM A/S

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Introduction

Log wood stoves contribute significantly to renewable heat production in Europe. But new efficiency and emission requirements are challenging. Therefore the project "WoodStoves2020" aimed at investigating and improving complete systems of a wood stove appliances, addressing all major technological aspects, from air supply, stove geometry, heat storage capability, sensors and electronics, up to the chimney and its components (Figure 1). Both, thermal efficiency and flue gas emissions were in the focus.

Results

Based on a sensor screening four gas sensor models were selected for experimental evaluation in a more than 500 resp. 250 hour long-term stove test; two different types of lambda probes (switching & broadband), a CO/O2 probe and an O2&CO combination sensor. The affordable lambda probes demonstrated a highly accurate oxygen determination throughout the whole evaluation, eventual impairment by aging or particle deposit has not been observed. The combination sensor, which also showed accurate O2 determination, as well as the CO/O2 probe enabled a reliable detection of CO gradients & overall ranges, thus proving their applicability. However current costs for sensor and electronics are seen as still too high for a broader use in the stove sector.

Within the project, various automated control systems were evaluated; both integrated systems and add-on solutions (retrofit systems). The integrated systems, temperature and flue gas sensor based control systems, consistently improved stove performance compared to manual operation of the same stove (fixed air flow). An example for that potential is seen in Figure 2, where gaseous emissions were reduced (CO: minus 20 – 32 %; OGC: minus 25 – 45 %) and thermal efficiency improved (by 1 – 2 %-points) for the same stove just by operating it with an automated control system (due to lower O2 levels). Another huge benefit of these systems will be the minimization of user induces errors.

The evaluation of retrofit control systems showed a significant potential for increasing efficiency (by about 1.5 – 4.6 %-points) and for reducing gaseous emissions (by about 40 – 56 %). However, particle emissions remained largely unchanged or were comparable to good manual stove operation.

A new low-emission stove with integrated PCM (phase change material) heat storage was also developed. Compared to state-of-the-art chimney stoves the new stove technology achieved lower emissions and significantly higher efficiencies (> 90 %). The market introduction of this new technology is expected for 2018.

Experimental evaluation of different types of catalysts (mesh, honeycomb and foam ceramic filters with catalytic coating) was another focus in the project. It could be shown that selection (type & material) and right placement in the stove are crucial to ensure an effective operation with adequate long-term stability. With a proper choice a significant reduction of gaseous emissions and particles can be achieved. Regarding carbon monoxide, for example, reduction rates of more than 90 % (up to nearly complete elimination) could have been observed for some models. Additionally, catalysts will also act as a safety device for severe combustion phases, since reduction rates for hydrocarbon and particles usually even increase at times with bad combustion & high emissions. A challenge in using catalysts will be the increased flow resistance, which is limiting their applicability. Therefore the aim should be to keep the pressure drop across the catalyst as low as possible and/or to use a flue gas fan to increase draft when needed.

However, tests over a whole heating period would be needed to be able to evaluate the long-term performance of catalysts for wood stoves. The assumption that PM reduction could also be achieved by using uncoated (non-catalytic) foam ceramic elements in stoves - as it was recently advertised by several stove manufacturers - couldn't be proven.

The influence of chimney draught (too low or too high) was also investigated. A draught stabilizer was tested and evaluated. It enabled an increased efficiency by approx. 10 %-points, but at the same time it also raised gaseous emissions (+23 %) and PM emissions (+14 %). Furthermore, recommendations regarding the implementation of flue gas fans to overcome cases of too low chimney draught were developed.

Regarding efficiency improvements, the standing heat losses from stoves through the chimney (i.e. losses after stove operation and cold standing losses) were investigated. For a modern 8 kW log wood stove they can amount to 750 kWh per year, assuming 100 heating cycles annually. The tests showed that these losses can be minimized nearly to zero when using automatically closing and tight air flaps or when automated combustion air control units are applied. But with the current prices of automatically closing air flaps and retrofit controllers the pay-off period is still too high (approx. 14 – 23 years).

Furthermore, a PCM heat exchanger was developed and integrated into a stove. It helps to store a relevant share of heat produced and to release it with delay to the room over a longer period. This improves the living comfort and makes such stoves more attractive for low energy buildings. It was

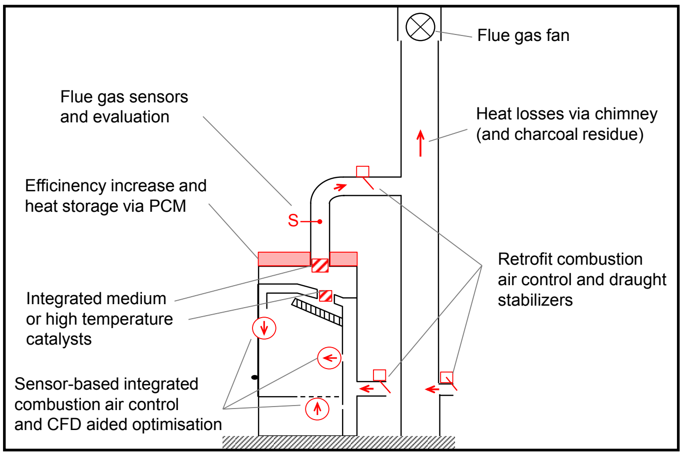
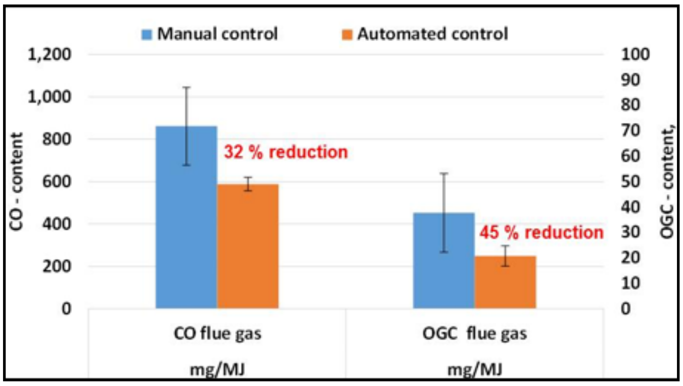


Figure 1: Overview on all system components regarded or optimized in the project. PCM: Phase Change Materials. CFD Computational Fluid Dynamics (source: TFZ)



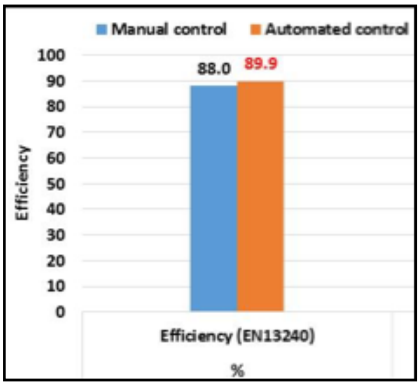


Figure 2: Emission reduction and effiency increase achieved by implementing an automated control system in a newly developed low-emission stove (Source: BIOS)

shown that more than 50 % of the heat produced can be stored in the stove and in the PCM material. The heat is then slowly released over night. According to the test runs performed the developed PCM heat exchanger shows a good heat storage capacity and is suitable for the integration in a wood stove (efficiencies > 90 % are possible).

All technologies investigated were comprehensively tested using a particularly developed and harmonized testing method which was closer to a realistic stove operation in practise, compared to today's type testing standards. Thus, all achieved results and performances can be also interpreted as directly achievable in field applications.

As an outcome of the project, three Technical Guidelines which comprise the main outcome of the project for manufacturers and other persons of interest were established. The Guidelines are focusing on optimized stove concepts, automated control systems for stoves, and on heat storage units based on PCM.

Acknowledgment

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