Cost-efficient sensor solution for reducing emissions from woodstoves through user guidance

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Woodstoves remain popular for heating and recreational uses, while at the same time being a major source of harmful gas and particle emissions in residential areas. There have been several technological improvements to woodstoves and related equipment (e.g., particle filters), and retrofitting older installations is often mandated by law. However, these technological improvements fail to account for the relatively large influence of the user [1]. Woodstoves with automatic air control are a possible solution, but these are expensive and therefore have a limited market share. In this project, an alternative approach is developed and investigated. A simple sensor system is installed on existing stoves, which gives the user direct feedback on e.g., air supply and refuelling intervals. Thereby, the user becomes part of the control loop, and improve firing techniques are reached, leading to lower emission of particles and harmful gasses.

Specifically, the system consists of a thermocouple and a low-cost oxygen probe from the automotive industry. The two sensors measure directly in the flue gas duct and are situated as close to the fire as possible. An algorithm was developed to connect the low-cost sensors with state-of-the-art equipment and determine the combustion quality, e.g., in terms of carbon monoxide (CO) , organic gaseous carbon (OGC) and particle emissions. Furthermore, knowledge of the air supply and 'optimal' user behaviour is implemented in the algorithm to assist the user.

Preliminary results indicate that the combination of temperature and oxygen concentration can be used to predict the progress and quality of combustion in a woodstove. The temperature measurement is strongly dependent on the placement of the measuring equipment and the woodstove model. We have analysed data to correlate combustion with type of wood (oak, birch, mixed), number and size of firewood, etc. All have influence on the quality of the combustion; however, none could be correlated directly with the measurements of CO, OGC, temperature, and oxygen because of the variance in data from charge to charge.

Currently, the prototype with sensors and algorithm is tested at end users and we will present preliminary results from this project. The new system is expected to reduce gaseous and particle emission by guiding the user towards correct firing techniques in real time, e.g., adjusting air flow and recharging at the proper time with the proper fuel.

[1] R. Mack, H. Hartmann, C. Schön, *Influence of user behaviour on emission from firewood stoves*, **2019**, *27th European Biomass Conference and Exhibition proceedings*, 409-418.