A Scientific Basis for the Development of the Next Generation of Biomass Burners

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An introduction to the work behind the development of the next generation of swirl stabilized burners for dedicated biodust combustion. A compilation of lab-scale derived chemical kinetics, CFD simulations, and full-scale measurements.

Background
Thermal conversion of biomass into heat and power is arguably the single most efficient way of utilizing the energy bound in any source of biomass. Its existence is required in order to balance out the fluctuating production from wind Mills and other alternative sources and to provide district heating.

Objectives
This work aims to establish a scientific basis for the development of a new generation of biomass burners designed to facilitate high electrical efficiency and fuel flexibility under stable operating conditions.

Content

\begin{itemize}
  \item **Classical Engineering Study**
    \begin{itemize}
      \item Particle morphology development
      \item Reaction kinetics
    \end{itemize}
  \item **CFD Modeling**
    \begin{itemize}
      \item Simplified sub-model structure and burner geometry
      \item Qualitative trend assessment
    \end{itemize}
  \item **Full-Scale Campaigns**
    \begin{itemize}
      \item Flame response to significant changes in process parameters
    \end{itemize}
\end{itemize}

Classical Engineering Study
Understanding the particle development, both physically and chemically, is a key aspect when shifting from conventional coal to biomass. Such information are derived from laboratory experiments at heating rates in the order of \(10^4-10^5\) K/s. The development in particle morphology is followed by SEM and both devolatilization and char burn-out kinetics are derived using TGA.

Full-Scale Campaigns
The full-scale campaigns provide much needed information on in-flame conditions during dedicated biodust operation. Flame mapping includes: gas phase temperatures, chemical composition using probe techniques while estimations of particle cloud velocity, surface temperature, and flame stability is assessed from optical observations in both the VIS and IR spectrum. The flame responses to significant changes in the operational conditions have been monitored.

Computational Fluid Dynamics (CFD) Modeling
Generic burner geometries and simplified sub-model construction are the key aspects of the modeling. Acknowledging that the properties of biomass are highly diverse, these models are used for qualitative trend assessments from which general design guidelines can be derived.

Summary
The kinetics derived from the classical engineering study are used to simulate the devolatilization and char burn-out phases in the CFD model. Likewise, the study on morphology development will be used to estimate suitable sub-routines, e.g. effective drag coefficients. The full-scale campaign is used to evaluate the results of the generic CFD models. As the qualitative trends can be reproduced, the CFD models can be used to extend the experimental matrix and facilitate process optimization.

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