doi: 10.1255/tosf.10

# Non-representative sampling versus data reliability—Improving monitoring reliability of fuel combustion processes in large-scale coal and biomass-fired power plants

**Name of candidate:** Claas Wagner
**Institution/University:** Doctoral School of Science and Technology: Biotechnology, Chemistry and Environmental Engineering, Aalborg University, Denmark
**Defense:** 2 December 2013
**Supervisors:** Professor Kim H. Esbensen, Hans S. Møller, Vattenfall, DK and Horst Faust, Pfaff/FLSchmidt

The impact of non-representative sampling on data reliability constitutes a critical factor for the validity of Process Analytical Technology (PAT) applications for industrial quality monitoring and control. The Theory of Sampling (TOS) is the only guarantee that ensures such reliability, as the only framework for complete understanding of heterogeneity and representative sampling. The primary application realm in this PhD concerns reliable process monitoring in coal and biomass-fired power plants, where combustion efficiency and atmospheric emission characterisation are of high priority. A fundamental requirement is reliable knowledge of fuel composition and its physical characteristics at all stages during unloading, grinding, mixing, pneumatic transportation and combustion. Where a sufficient alternative biomass fuel resource platform is available, conversion of coal-fired power plants is high on the agenda, in Denmark, in Europe and (to a lesser degree) globally. The present focus in Denmark is on wood pellet-fired power plants. In order to accurately control fuel quality, combustion and grinding processes, representative samples need to be extracted at all critical stages in the processing flow path.

The main practical goal of the PhD project has been to develop a new sampling device, termed the "EF-sampler" (Figures 1 and 2), allowing extraction of representative samples from pulverised particulate material streams transported in pressurised pipes, specifically in the section between mill and burners. This is a critical process location since characteristics such as particle size distribution and moisture content have direct impact on combustion efficiency and thus must be known with the best available validity. Pipe sections used for pneumatic transportation of pulverised material streams are mostly set up horizontally, however, causing a risk for severe segregation during sampling. Currently no reliable sampling device exists on the market that can perform representative sampling for pulverised particulate material streams in a horizontal flow, hence development of the EF-sampler. The present R&D also contributes to monitoring optimisation by means of acoustic chemometrics as a possible PAT application for biomass size distribution characterisation, in which reference sample representativity is critical for prediction model validation. Overall the PhD stresses the need for further integration of the TOS in current international standards as well as contributes to a call for reconciliation between the metrological measurement uncertainty (MU) concept and TOS.

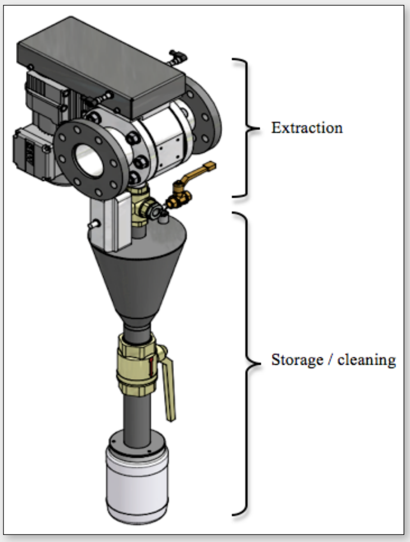


Figure 1. Schematic overview of the EF-sampler. Upper part shows the extraction mechanism including electric power supply and extraction mechanism with enclosed sampling arm. Lower part represents the storage/cleaning section including compositing cylinder, pressure valve, storage valve and storage container.

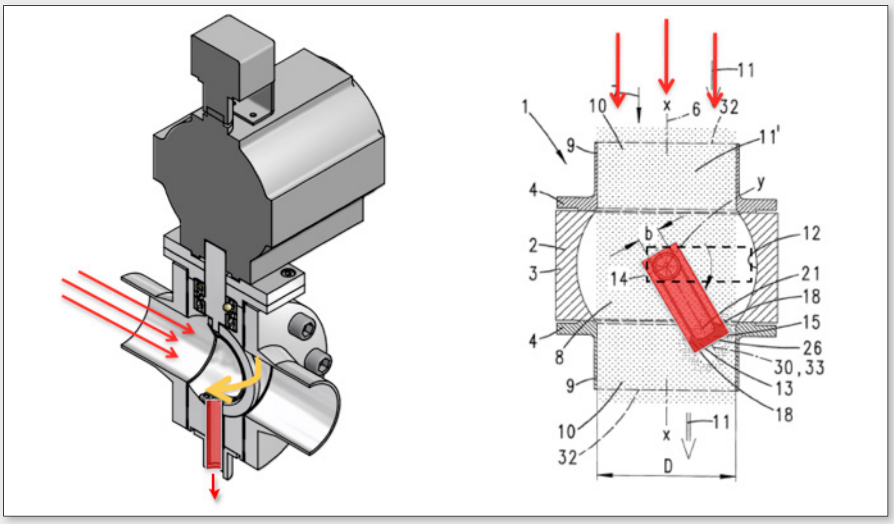

Figure 2. Schematic overview of the EF-sampler. Left figure showing side view, illustrating material flow direction, rotational movement of cutter arm and recovery of extracted material through outlet chute. Right figure shows top view of sampler, highlighting the rotational movement of the sampling arm, ducted material flow direction (top arrows) and parking position of sampling arm (dashed line).