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Comparison of Cyclone Design Methods for Removal of Fine Particles from Plasma Generated Syngas

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Abstract : A waste-to-energy plasma system was designed by Necsa for commercial use to create electricity from unsorted municipal waste. Fly ash particles must be removed from the syngas stream at operating temperatures of 1000 °C and recycled back into the reactor for complete combustion. A 2D2D high efficiency cyclone separator was chosen for this purpose. During this study, two cyclone design methods were explored: The Classic Empirical Method (smaller cyclone) and the Flow Characteristics Method (larger cyclone). These designs were optimized with regard to efficiency, so as to remove at minimum 90% of the fly ash particles of average size 10 μm by 50 μm. Wood was used as feed source at a concentration of 20 g/m³ syngas. The two designs were then compared at room temperature, using Perspex test units and three feed gases of different densities, namely nitrogen, helium and air. System conditions were imitated by adapting the gas feed velocity and particle load for each gas respectively. Helium, the least dense of the three gases, would simulate higher temperatures, whereas air, the densest gas, simulates a lower temperature. The average cyclone efficiencies ranged between 94.96% and 98.37%, reaching up to 99.89% in individual runs. The lowest efficiency attained was 94.00%. Furthermore, the design of the smaller cyclone proved to be more robust, while the larger cyclone demonstrated a stronger correlation between its separation efficiency and the feed temperatures. The larger cyclone can be assumed to achieve slightly higher efficiencies at elevated temperatures. However, both design methods led to good designs. At room temperature, the difference in efficiency between the two cyclones was almost negligible. At higher temperatures, however, these general tendencies are expected to be amplified so that the difference between the two design methods will become more obvious. Though the design specifications were met for both designs, the smaller cyclone is recommended as default particle separator for the plasma system due to its robust nature.

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