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An experimental study on mineral particle deposit formation and sintering in cement calciner

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During cement manufacturing, mineral particle deposition is frequently found on the walls of process equipment, influencing production efficiency and stability of operation. Excessive deposition can build up to tens of centimeters in thickness and tens of meters in length without regular cleaning, leading to equipment degradation, flue gas channel obstruction, and even unexpected plant outages. This study aims to improve the understanding of mineral particle deposition in cement manufacturing plants, which is currently limited.

Particle deposition experiments were conducted with cement mineral materials in a laboratory-scale entrained flow reactor, combined with a ceramic deposit probe system with a probe surface temperature of 700°C to 1200°C, mimicking the temperature conditions in a cement calciner. The effects of fed materials (raw meal, hot meal, bypass dust), furnace temperature (700℃-1200℃), and gas velocity (0.9m/s-1.8m/s) on deposit formation rate were investigated. The results showed that the amount of KCl in the feed materials has a significant impact on deposit formation. The hot meal and bypass dust samples were obtained from a cement plant firing some solid recovered fuel (SRF) and contained a high level of K and Cl (a sum of 2 wt% for hot meal and 10 wt% for bypass dust). The large amount of K and Cl in hot meal and bypass dust seems to increase deposit formation rate by melting of KCl in the temperature range of 700°C to 1000°C. In addition, the deposit formation rate of the three materials was enhanced and became similar at 1200°C which was attributed to the melting of mineral particles. Due to the increased possibility of particle rebound, a higher gas velocity resulted in a lower deposit formation rate.

Sintering tests of hot meal were performed in a laboratory-scale force gauge oven, equipped with an electrical actuator arm to debond and quantify the adhesion strength of the artificial mineral deposit. The effects of sintering temperature (700°C-1000°C), amount of KCl in mixture (0%-60%), sintering time (4h-24h), and measurement temperature (700°C-850°C) on adhesion strength of deposits were studied. The obtained results showed that the presence of KCl promoted the adhesion strength considerably around 750°C, due to the partial melting of KCl particles. However, KCl had almost no influence on the adhesion strength at 700 °C and 800 °C. At 750 °C, the adhesion strength rose from roughly 25kPa to 450kPa as the proportion of KCl in the mixture increased from 0% to 60%. The sintering time appeared to reduce adhesion strength marginally in investigated cases.