Cold End Inserts for Process Gas Waste Heat Boilers

Overview
Air Products, operates hydrogen production plants, which utilize large waste heat boilers (WHB) to cool process syngas. The gas enters at approximately 1558°F and leaves at approximately 555°F. Due to this large temperature change, the gas velocity dramatically reduces and allows particles entrained in the flow to fall out of suspension and foul the WHB tube walls. Air Products tasked our team to design an insert to place in the tubes of the WHB to increase flow velocity, thereby reducing fouling of the WHB.

Objectives
Air Products wishes that our team determine a critical velocity at which particles remain entrained in the flow. Then an insert which will achieve a flow velocity above this critical velocity will be designed. This insert also needs to not cause a pressure drop of over 10 psi across the WHB tubes and have a minimum effect on heat transfer.

Approach
• An experiment to measure the particle entrainment velocity as well as velocity increase and pressure drop caused by various inserts was designed and constructed.
• Critical velocity for particle entrainment was determined
• Calculations were performed for the velocity increase caused by various insert designs and geometries.
• Different concepts for insert designs were generated and two main designs selected.
• ½”, ¾”, 1” and ½” to 1” tapered inserts were constructed for testing.
• Test data was used to determine change in velocity and pressure drop caused by each insert.
• Correlations were developed to relate our results to what will be experienced in a WHB.

Outcomes
After completing this project, the objectives were reached, and some important factors were determined:
• The critical velocity for particle entrainment was found to be approximately 4 m/s.
• A tapered insert increasing from ⅜” to ⅝” diameter was chosen as the ideal insert design which satisfies all 3 design criteria.
• Correlations relating our experimental results to a waste heat boiler’s operating conditions were developed.