Thermal performance enhancement of non-premixed syngas combustion in a partial combustion unit by winged nozzle: Experimental and CFD study

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ABSTRACT

This paper presents the effect of nozzle assembly design on the performance of a partial combustion unit (PCU) using the scale-adaptive simulation (SAS) and non-intrusive laser measurement techniques. Four different configurations were tested, namely, nozzle without wing and three nozzles with wing, i.e., flat surface wing, semi-sphere hollow wing and bent wingtip. The syngas-oxygen reaction chemistry was calculated using non-premixed flame model incorporated with GRI-MECH 3.0 mechanism. The radiative heat transfer was modelled using the discrete ordinates (DO) model. The simulation was compared with the particle image velocimetry (PIV) and a two-dimensional laser doppler anemometry (LDA) measurement on a scaled-down PCU model. A good agreement between the SAS prediction and experimental measurement was obtained. It was found that the modified nozzle assembly design with a semi-sphere hollow wing yielded the highest combustion temperature owing to the intense turbulence-induced recirculation mixing of oxy-fuel. The modified nozzle assembly design introduced in this work increased the peak outlet combustion temperature up to 18 higher compared to the original design. The finding in this work may useful for design retrofits of a combustion system.

KEYWORDS:

Winged nozzle; Combustion; Scale-adaptive simulation; PIV; Laser Doppler anemometry; Turbulence

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