

Stability and Emission Characteristics of Swirl Stabilized Blended Fuel Flames

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Abstract

Swirl, a major design factor in the primary zone of combustor is introduced into the premixed burner to understand the performance of flow mixing characteristics, flame stability and emissions produced by the lean premixed swirl burner (LPSB) using variable low calorific value fuels (LCV) fuels. Two swirls with vane angles, 30 degrees and 45 degrees are fabricated and their flow characteristic on LPSB is initially analyzed in terms of velocity and turbulence intensity profiles using hot-wire anemometry. These profiles are studied for better understanding of flame stability limits while combusting LCV fuel compositions. As observed in earlier researches, results demonstrated that swirls with greater (degree) vane angles showed a wider flow region indicating more stable combustion conditions. The test-matrix comprised of various natural gas compositions and syngas fuels. The detailed analysis provides the flame blow-off limits and emissions data obtained for different swirl/fuel combinations. Emissions measured by gas analyzer demonstrated that higher degree of swirls enhanced lean combustion processes and reduced major pollutant emissions, NO_x and CO. Overall analysis of research shows that LCV fuels show extensive performance and can replace natural gas to produce energy efficiently in land based power generation systems.

Nomenclature

TI = turbulence intensity
U = air velocity
LPSB = lean premixed swirl burner

I. Introduction

Turbine combustors of advanced power systems have goals to achieve very low pollutants emissions (NO_x < 2-ppm), fuel variability, and fuel flexibility.¹ Future generation gas turbine combustors should tolerate fuel compositions ranging from natural gas to a broad range of syngas without sacrificing operational advantages and low emission characteristics.¹⁻² Additionally, current designs of advanced turbine combustors use various degrees of swirl and lean premixing for stabilizing flames and controlling high temperature NO_x formation zones.³⁻⁴ However, issues of fuel variability and NO_x control through premixing also bring a number of concerns, especially flame stability and flame flashback.

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