Sustainable power generation resulting in low pollutant emissions, such as CO2 and NOx, poses a very challenging task in the near future. Premixed combustion of hydrogen-rich fuels in gas turbines is a promising approach to cope with ever more stringent regulations on emission levels. This method, however, involves the risk of flame flashback from the desired flame position into the premixing section, leading to catastrophic failure of the machine components that are not designed for such high temperatures. The objective of the current study was to visualize and describe the transition from stable flame to flashback in a generic H2-air combustion system and develop a physics-based model for the description of the transition. In order to achieve the high temporal and spatial resolution required for capturing the involved effects, high-speed particle image velocimetry (PIV) and high-speed planar laser-induced fluorescence (PLIF) were employed. In order to characterize the interaction of the flame with the flow in detail, both measurement techniques...
were applied to very small fields-of-view using (UV) long-distance microscopes. The repetition rates were 20 kHz for PLIF and 3 kHz for PIV, respectively. During both the PLIF and the PIV measurements, the flame's OH-chemiluminescence was captured from a perspective perpendicular to that of the PLIF/PIV camera for further flame characterization. The microscopic measurements revealed that there is a negligible influence of the unconfined flame on the incoming burner flow in stable mode. Upon approaching the flashback conditions, however, the velocity profile of the burner flow is distinctly distorted by the presence of the flame inside the premixing duct. The flow directly upstream of the flame is retarded and deflected around the leading flame tip. Based on the effects observed in the experiments, a new flashback model is proposed, which identifies the heat transfer to the burner rim and the flame speed as the main drivers for the onset of flashback, whereas the flame backpressure is the governing factor for the subsequent upstream flame propagation. © 2016 by ASME.