Stability of premixed methane-air swirled flame

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The structure of non-reacting swirling jets is known to be largely dependent on the degree of swirling and the way of swirling. [1]. Helical instability modes are amplified, the vortex core breaks up, and a recirculation zone appears when the mixing layer swirls sufficiently. Thermal expansion effects are superimposed on top of all the other effects in reacting swirling flows. As a result, flow swirling is commonly used as a method for forming large-scale vortex structures. The presence of stagnant recirculation zones in such structures allows for an increase in the reaction products' contact time with the fresh fuel-air mixture. The fuel-air mixture is heated during contact, which facilitates ignition, in turn the vortex core's precession significantly increases the intensity of heat and mass transfer. All of this improves combustion stability, especially in lean combustible mixtures. This highlights the importance of studying the nature of the stability of reactive flows with large-scale vortex structures. Gravity, through the buoyancy, is known to play a significant role in the dynamics and stabilization of the flame, as well as other characteristics. Because there is a competition between the buoyancy forces and the flow energy in this case, the lower the flow velocity, the greater the influence. When swirling, the recirculation zone is just an area with a reduced velocity, which means that it is subjected to a noticeable effect from gravitational forces. This shows the expediency of analyzing the influence of gravitational forces on swirling reacting flows.

The limits of stable combustion of a swirling methane-air flame under normal and reverse gravity are investigated in the present study. The burner is a Vitoshinsky nozzle with a contraction length of 28 mm and an inlet diameter of 30 mm and an outlet diameter of 15 mm. A bladed swirler was placed inside the nozzle to swirl the flow. In the work, the swirl coefficient ranged from 0.4 to 1.2. A constant temperature hot-wire anemometer was used to assess the dynamic characteristics of a swirling isothermal flow (measuring the mean value and standard deviation of the velocity). The stability of the flame under various gravitational conditions was estimated based on the stability diagram. In the coordinates of flow rate versus fuel equivalence ratio, the parameters of dettaching, re-attaching and blow off were determined for conditions of normal and reverse gravity. Under normal and reverse gravity conditions, the results are compared for a flow without a swirler and for a flow with a swirler. It can be seen that the boundaries of a complete blow-off are in conditions of significantly higher velocities in reverse gravity compared to normal gravitational conditions. At the same time, such a swirler does not affect the blow-off conditions for +1g conditions, and the effect becomes noticeable under reverse gravity conditions, and grows with an increase in the excess of fuel in the mixture. In this case, the swirl allows you to get a detached and re-attached flame.

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References

1. H. Liang, T. Maxworthy, *J. Fluid Mech.* **2005**, 525, 115.