

MOHAMMED ALKHABBAZ and V'YACHESLAV AKKERMAN, Dept. of Mechanical and Aerospace Engineering, West Virginia University, Morgantown, WV, 26505. Influence of Fuel Nonequidiffusivity and Wall Boundary Conditions on Finger Flame Acceleration in Pipes

Among the mechanisms of premixed flame acceleration in pipes, finger flame acceleration (FFA) experiences the following scenario: an initially hemispherical flame embryo, ignited at a closed end of a tube or a channel with one end open, at its centerline, eventually acquires a convex, finger-like shape. This is accompanied by powerful acceleration, which lasts until the flame skirt contacts a sidewall of a pipe, and is followed by flame deceleration and formation of a concave, tulip flame. Previous theoretical studies of FFA employed conventional simplifying assumptions – such as equidiffusive ($Le=1$) combustion and ideally slip, adiabatic walls – which are not the cases in the practical reality. In contrast, the present work investigates the impacts of the Lewis number, Le , and various wall boundary conditions on FFA. The study is performed by means of the computational simulations of combustion equations, with fully-compressible hydrodynamics, transport properties and Arrhenius chemical kinetics. Evolutions of the major flame parameters, such as the locus and velocity of the flame tip as well as the flame surface area, are observed. It is shown that $Le>1$ flames are intrinsically thickened and thereby propagate slightly slower than equidiffusive ones, however the effect is minor. In contrast, $Le<1$ flames propagate faster due to the onset of the diffusional-thermal instability. As for the wall conditions, various mechanistic (slip/nonslip) and thermal (adiabatic/isothermal) boundaries are employed and compared. Unlike other acceleration mechanisms, such as that due to wall friction, it appears that sidewalls provide a minor impact on FFA, presumably, because this acceleration occurs mainly far from the walls.