Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Analytical and Computational Study of Flame Acceleration due to Wall Friction in Combustion Tubes and Channels BERK DEMIRGOK, V'YACHESLAV AKKERMAN, West Virginia University — Deflagration-to-detonation transition constitutes one of the fundamental problems within the studies of reacting flows. It occurs when a subsonic flamefront accelerates, with velocity jump by several orders of magnitude. According to the Shelkin model, the key element of the process is wall friction at non-slip walls, driving a flow of the fresh pre-mixture to be non-uniform, leading to a positive flame-flow feedback and thereby flame acceleration. We perform analytical and computational study of the phenomenon, with very good agreement between them in the domain of intrinsic accuracy of the theory. Theory assumes large Reynolds number (Re) and thermal expansion as well as plane-parallel flow ahead of flamefront. Simulations are performed for complete set of combustion and hydrodynamic equations. Analytical and computational results are also validated by recent experiments on ethylene-oxygen combustion. It is proven realistic flames with a large density drop at the front accelerate in a self-sustained manner and may initiate detonation in a sufficiently long tube. Before this event, the flame shape and the velocity profile remain self-similar. Acceleration rate grows with thermal expansion in the burning process but decreases with Re related to flame propagation.

Berk Demirgok
West Virginia University

Date submitted: 01 Aug 2013

Electronic form version 1.4