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EXACT FLAME-FRONT TRACKING IN PREMIXED LOW MACH NUMBER COMBUSTION

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In this project, we want to improve the design of dust explosion suppression systems. Such devices are vital in industries dealing with fine-grained explosible dusts suspended in air inside of confined volumes. Currently, simple one-dimensional models which assume spherical symmetry are used for dimensioning. Key points of this work are to gain a better understanding of the principle physical mechanism behind flame propagation and to improve the prediction of pressure rise in non-spherical configurations. One aspect for simulating premixed combustion inside a closed vessel is tracking of the flame. In this talk, we will present a new method to capture the front exactly. Currently, we consider the problem in two dimensions. We plan to extend to three-dimensional rotational symmetric geometries and to account for explosion venting.

Experiments show that the flame zone propagates with an almost constant relative speed. Thus, we model the front as an infinitely thin sheet moving with a curvature-dependent relative speed, also known as the Markstein model. This model is unstable to pertubations of wavelengths above a critical wavelength which depends on the Markstein length[1]. We assume that the unburnt and burnt fluid is an ideal gas with constant material parameters, and we ignore heat conduction and friction. This implies that every material element preserves its entropy except when crossing the front. We expand our equations with respect to a small reference Mach number. In leading order, pressure, jump of speed at the front, density in the unburnt and divergence of the velocity field are time-dependent only. We split the velocity field in an irrotational and a solenoidal part with a scalar and vector potential, which permits the solution of two easier sub-problems.

The scalar potential satisfies a Poisson equation where the right-hand side is time-dependent only. Therefore, we use a boundary element method called panel method[2] which we adapt for internal flow. The flame front is described by a set of panels, i.e. connected line-source elements. We fulfil the jump conditions for normal velocity by a source strength distribution that is time-dependent only. The motion of the front is given by the solution of a simple equation of motion. We present first results for non-spherical configurations.

REFERENCES

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