Validation of a Multidimensional Smouldering Model

Smouldering is a flameless form of combustion driven by exothermic oxidation surface reactions within a porous medium. Smouldering is being harnessed by engineers to remediate liquid hydrocarbon and Per- and polyfluoroalkyl substances (PFAS) contaminated soils, drive waste-to-energy processes, and to provide off-grid sanitation solutions in the developing world. In all applications, initial heat is supplied to a small ignition region and air is injected to support self-sustaining smouldering. However, engineers and researchers have only a few tools to utilize and study smouldering, and this is a key limitation. This work addresses this limitation via developing a novel multidimensional, thermodynamic-based smouldering model. This model is valuable for both engineers and researchers to gain a deeper understanding into key physical (e.g., temperature, air flow, and oxygen distribution), chemical (e.g., a non-uniform oxidation reaction), and operational processes in smouldering systems (e.g., the effects of radial heat losses on energy efficiency). As smouldering gains popularity as a novel technology, there is a growing need for robust smouldering models.

This presentation highlights both the model development and validation from highly instrumented experiments. These results highlight the processes that govern key operational characteristics, such as peak temperature and air flow distributions (critical for PFAS remediation) and overall energy efficiency (critical for waste-to-energy and sanitation purposes). Altogether, this work is anticipated to support investigating, designing, and optimizing the future smouldering systems for a range of applications such as PFAS remediation, waste-to-energy, and improving sanitation in the developing world.

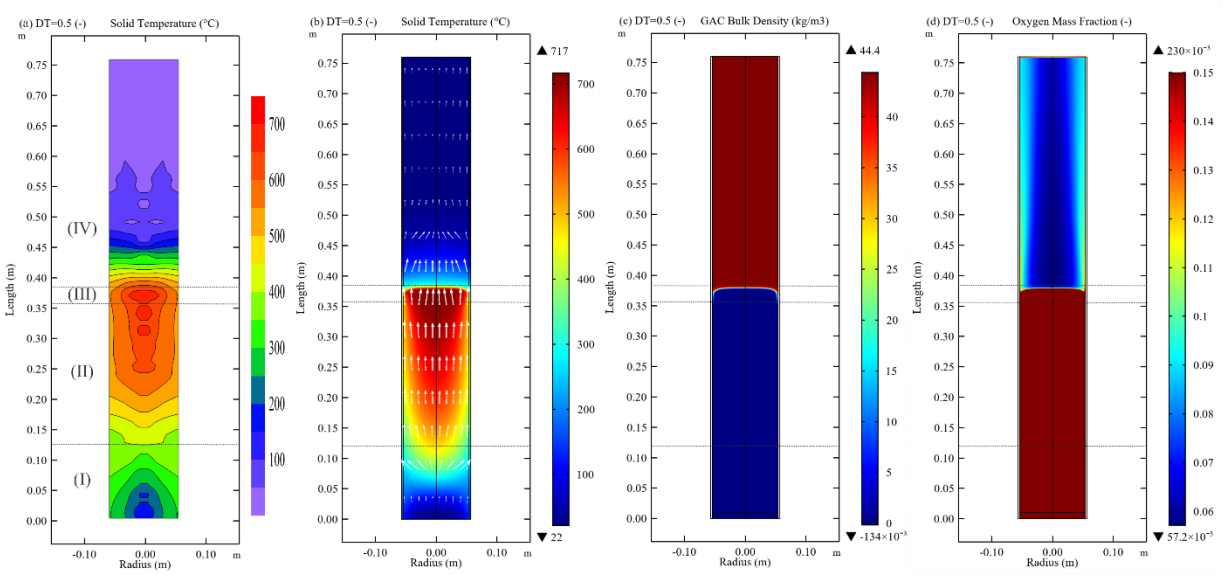

Figure 1. 2D contour of a) temperature distribution (Experimental) , b) temperature distribution (Numerical), c) GAC bulk density distribution and smouldering front position and shape, d) Oxygen mass fraction consumption