Combustion of a polymethyl methacrylate sphere in air

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Polymethyl methacrylate (PMMA) – is a synthetic polymer of methyl methacrylate (MMA, $C_5H_8O_2$), thermoplastic transparent plastic, widely used in industry, construction and everyday life. Due to its useful properties (transparency, resistance to moisture and microorganisms, electrical insulating properties) it is used as a structural, optical and decorative material. The main disadvantage of PMMA is its low heat resistance. At temperatures above 200oC, PMMA depolymerizes to form a monomer - methyl methacrylate. Thus, the study of flame propagation over surface of such polymers is very important task for fire safety investigations. CFD (Computational fluid dynamics) – is a modern and accurate simulation method available to conduct such studies.

The aim of this work is to study the propagation of flame over the curved surface of PMMA under normal conditions. For this purpose, CFD simulation of the combustion process, based on experimental data, was carried out with the inclusion of a detailed kinetic model of the PMMA oxidation. The object of research was a sphere made of cast PMMA with a diameter of 40 mm burned in still air. Temperature, mass loss rate, concentration profiles of the main products and reactants near the combustion surface were obtained experimentally. The gas dynamic flow and combustion were calculated using the ANSYS Fluent software package [1] with the full set of Navier-Stokes equations. The PMMA conversion mechanism includes a surface reaction describing polymer pyrolysis and MMA oxidation chemistry in the gas phase. To speed up the calculations the reduced gas-phase kinetic mechanism, including only 29 components and 44 reactions, was used [2]. This mechanism was obtained with the mechanism reduction procedure implemented in the Mechanism Workbench software package (Kintech Lab) [3]. The rate constant of PMMA pyrolysis was taken from the previous studies [4].

As a result of calculations, the fields of temperatures, gas flow velocity and mole fractions of substances in the flame were obtained. A comparison of the simulation results and experimental data showed that the proposed model satisfactorily describes the combustion of a PMMA sphere and can be used to describe the combustion of other objects, in particular, the combustion of PMMA plates.

References

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