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硼颗粒聚团着火过程研究

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Study of Ignition Process of Boron Particle Agglomeration

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摘要

针对含硼推进剂固体火箭冲压发动机内硼颗粒聚团的着火过程开展了系统研究,考虑硼颗粒聚团内部气相扩散及颗粒聚团与周围环境的传热传质过程,建立了一维硼颗粒聚团着火模型,详细分析了环境总压、环境气体温度、氧气摩尔分数、聚团半径、聚团孔隙率以及硼颗粒粒径对硼颗粒聚团的着火温度和着火延迟时间的影响规律。结果表明:硼颗粒聚团能够在比单颗粒硼着火温度更低的环境温度下实现着火,且着火温度随聚团半径、氧气摩尔分数的增加而降低,随环境总压、聚团孔隙率以及硼颗粒粒径的增加而增大;硼颗粒聚团着火延迟时间随环境气体温度、氧气摩尔分数和颗粒聚团孔隙率的增加而减小,随硼颗粒粒径的增加而增大。在较高的环境总压下,硼颗粒聚团的着火延迟时间随环境总压增加而增大。

关键词： 固体火箭冲压发动机 硼颗粒 着火模型 着火温度 着火延迟时间

Abstract:

The ignition process of boron particle agglomerations in boron containing propellant ducted rockets is studied systemically. A one-dimensional model is proposed taking into consideration the gas phase diffusion process in the boron particle agglomeration, and the heat transfer and the mass transfer process between the boron particle agglomeration and the surroundings. The influence of total ambient pressure, gas temperature, oxygen mole fraction, agglomeration radius, agglomeration porosity, boron particle radius on ignition temperature as well as the influence of these factors on ignition delay time are analyzed in detail. The results show that the ignition temperature of boron particle agglomerations is much lower than that for single boron particle. And the ignition temperature decreases with the increase of the agglomeration radius and the oxygen mole fraction, but increases with the increase in the total ambient pressure, the agglomeration porosity and the boron particle radius. The ignition delay time of boron particle agglomerations decreases with the increase in the ambient temperature, the oxygen mole fraction and the agglomeration porosity, while it increases with the increase in the boron particle radius. Under high total ambient pressures, the ignition delay time increases with an increase in the total ambient pressure.

Keywords: ducted rocket boron particle ignition model ignition temperature ignition delay time

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