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首页 | 大会组委会 | 会议剪影 | 专题研讨会 | 日程安排 | 重要日期 | 住宿 | 交通 | 联系我们

文章搜索

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论文资料

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专 题: 高超声速推进

中文标题: H₂/Air连续旋转爆震的试验实现及传播过程的三维数值模拟英文标题: Experimental realization of H₂/Air continuous rotating detonation wave and three-dimensional numeric

中文摘要: 在环缝-喷孔对撞式喷注模型发动机上,采用H₂/O₂热射流切向喷注的起爆方式,进行了H₂/Air组合的连续旋转爆震试验,试验成功起爆并实现了爆震波的持续旋转传播。切向喷注的热射流并没有直接诱导形成旋转爆震波,从点火到形成稳定传播的旋转爆震波之间存在时间间隔。高频信号时频分析结果表明,在该试验工况下,旋转爆震波的传播过程非常稳定,其传播频率在5.35-5.85kHz之间,平均传播频率为5.61kHz,对应的平均传播速度为1674.31m/s,达理论值的85.0%。对相应流量和燃烧室构型下的连续旋转爆震过程进行了三维数值模拟,由于数值模拟采用恰当量比的H₂/Air预混气,忽略了H₂/Air的混合过程,因此其燃烧效果更好。所得平均传播频率为6.27kHz,对应的平均传播速度为1870.1m/s,达理论值的94.93%。对试验和数值结果的燃烧室外壁平均压力沿程分布进行了对比,两者的变化趋势吻合较好,但是压力值存在一定的差别。

英文摘要: Results of both experimental and three-dimensional numerical studies on H₂/Air continuous rotating detonation are presented. Tangentially injected H₂/O₂ hotshot jet was used to ignite the engine successfully. Under the condition of air and hydrogen mass flow rates of 265 g/s and 7.7 g/s, and the ambient pressure of 11 kPa, H₂/Air continuous rotating detonation has been realized for about 300 ms. The variation of detonation wave propagation frequency during the process was 5.35-5.85 kHz, with the mean value of 5.61 kHz, and the mean propagation velocity at the mean combustor diameter was 1674.31 m/s, which was 85.0% of the theoretical CJ velocity. Due to the limited functions of the measurement system, corresponding three-dimensional numerical simulation was carried out. Flow field structure of the rotating detonation wave was analyzed, and the curvature effect was also considered. Propagation processes of both the experiment and simulation results were compared. The variation of detonation wave propagation frequency of the simulation case was 6.262-6.27 kHz, with the mean value of 6.266 kHz, which was larger than the experiment result. Distribution of the mean combustor pressure along the axis direction was analyzed. Within the heat release zone, the mean pressure decreased greatly, and it changed gently beyond this zone. The changing tendency of both the experimental and numerical results agreed with each other, but there were differences between the pressure values.

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