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等离子体气动激励控制激波的实验研究

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Experimental Investigation on Shock Wave Control by Plasma Aerodynamic Actuation

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摘要 在机械式和气动式激波控制方法的基础上，提出了激波控制的等离子体气动激励方法。采用电弧放电等离子体气动激励方式，设计了电弧放电等离子体气动激励器，在小型暂冲式超声速风洞中开展了等离子体气动激励控制尖劈斜激波的实验研究。结果表明，等离子体气动激励能够有效控制激波。实验研究了磁场对激波控制效果的影响，结果表明施加磁场使得激波控制效果显著增强。从热效应机理角度出发，建立了等离子体气动激励控制激波的热阻塞模型，采用该理论模型预测的激波变化规律与实验结果一致，从而验证了热阻塞模型的合理性。由于等离子体气动激励方法具有响应迅速、控制灵活等优点，因此将成为激波控制领域一条新的有价值的技术途径。

关键词： 激波 等离子体气动激励 电弧放电 超声速风洞 磁场 热阻塞

Abstract： Based on the mechanical and aerodynamic methods of shock wave control, a method of plasma aerodynamic actuation is proposed. The arc discharge type of plasma aerodynamic actuation is adopted and the actuator is designed. Then, wedge oblique shock wave control by this plasma aerodynamic actuation is experimentally investigated in a small-scale short duration supersonic wind tunnel. The test results show that the plasma aerodynamic actuation controls the shock wave effectively. Moreover, the influence of a magnetic field on shock wave control is studied and the test results show that magnetic fields greatly reinforce the shock wave control effect. Based on the thermal mechanism of shock wave control by plasma aerodynamic actuation, a thermal choking model is constructed, and the forecasting results of its theoretical shock wave transformation rules are consistent with the test results, which demonstrates that the thermal choking model is rational. As the method of plasma aerodynamic actuation possesses obvious advantages of rapid response and flexible control, it may become a new promising means in shock wave control field.

Keywords： shock waves plasma aerodynamic actuation arc discharge supersonic wind tunnel magnetic field thermal choking

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