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Study of effects from local energy deposition in supersonic gas flow on well-streamlined body

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Abstract

This work devoted to the investigation of effects that occur after local energy deposition in front of a well-streamlined body in supersonic flow. Local energy deposition was produced using an interelectrode direct current discharge. Under a well-streamlined body, one is assumed a wedge with apex angle of about 14 degrees. We carried out numerical calculations and experimental studies of interaction between the gas region, which heated by discharge, with a shock wave on the body. As a result of interaction, a strong change in the nature of flow near the body was observed.

Keywords: *energy deposition, supersonic, well-streamlined body.*

Introduction

Energy deposition in a supersonic flow is one of the effective methods of flow control. The contribution of energy can be carried out in various ways, for example, using laser or microwave discharges. After the energy deposition, a heated rarefied gas region is formed. As a result of the interaction between heated region and shock wave on the body, the flow pattern significantly changes. This method of flow control has the potential to solve the problems of super- and hypersonic flight, since it has a high speed reaction and the possibility of a targeted influence, which allows to get predictable changes in the required flow parameters.

The first results of works in this area began to appear in the 80-90s. Since then, many theoretical and experimental studies have been carried out. The main subject of the analysis are the consequences of interaction between a heated gas region with a shock wave on the body, such as, for example, the drop in stagnation pressure and vorticity formation. In works [1,2], a numerical simulation of the interaction between gas region, which heated by microwave and laser discharges, and blunt cylinder was carried out. It is shown that when the heated gas region begins to touch the shock wave, then on the boundary of the heated region the density and pressure gradient vectors cease to be collinear and the formation of a vortex begins. At the same time, the shock wave begins to move along the hot tunnel towards the incoming stream. Since vortex formation takes place at the interface between two media with different densities during the passage of the shock wave, this vortex structure can be attributed to Richtmyer-Meshkov instability. As a result of the further passage of the hot trail upstream, a pressure drop occurs at the critical point of the cylinder and the surface pressure distribution as a whole changes. These effects are confirmed by experimental works [3,4], in which change of flow nature and pressure at the critical point of cylinder after the microwave discharge is studied.

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In general, the work done previously was aimed at studying the effect of energy on blunted bodies. And discharge was usually located on the axis of symmetry of the streamlined body. Therefore, we decided to perform numerical simulation and experimental study of the effect on a well-streamlined body under various configurations of the discharge: the angle between the heated area and velocity vector of oncoming flow varied from 0 to 90 degrees.

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