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Dynamics and Vibroacoustics of Machines

Air flow control around the cylindrical rotating model by means of rotating electric arc in an external magnetic field

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Abstract

Theexperimentalinvestigationandnumericalmodellingof flow around a cylinder witha localizedheatsourceis carried out. Thelocalizedheatsourceissimulatedby MHD - actuatorwherea plasmaarcismoving under the influence of Lorentz force in the radial magnetic field aroundalong acylinder. Itisshownthatthe presence of a rotating heat source leads to breaking of the external flow of symmetry, and the appearance of non-zero lift force and circulation.

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Keywords: Acnuator, flow, magnetic field, lift, circulation

1. Introduction

At present, investigations in plasma aerodynamics are being conducted intensively [1-6]. The main background of these investigations is the control of streamlining of aerodynamic bodies by use of local plasma formations near their surfaces. One of the most popular devices used for this purpose are plasma actuators. The main advantage of plasma actuators is their performance, which is based on the electronic control of the parameters of electrical discharges.This property, in turn, allows us to implement feedback for control of the development of various gas-

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dynamic perturbations in the flow near the streamlined bodies, for example, to control the transition of the laminar boundary layer at a turbulent flow separation, etc.

One of the important problems of the plasma aerodynamics is control of flow circulation around a streamlined body, such as a cylinder, wing, etc. However, the number of works devoted to this problem is small [5,7]. In this paper we study the flow structure around a cylinderwith magneto-plasma actuator, Fig. 1.

Fig. 1. Integral image of the rotating electric arc on the surface of the cylindrical model.

Rotation of the electric arc leads to the gas flow entrainment near the wall and appearance of a non-zero circulation around the cylinder. Therefore, the aims of this work are experimentalmeasuring of velocity profile around the cylinder via shadow and PIV methods, as well as experimental and theoretical searching of induced circulationΓ and lift force.

2. Experimental measurements

To study the flow structure near the cylindrical surface induced by rotating an arc in an external magnetic field, the PIV and the shadow methods are used. Shadow setup includes excimer KrF laser, mirrors, lenses and projection screen. The excimer laser has a wavelength λ = 248 nm, pulse width equal to 10 nsec and pulse energy equal to 10 mJ. Optical images of gaseous heterogeneities are recorded by speed camera. The lift and drag forces collecting on the model were measured usinga Tenzo-M (PD-004) dynamic converter.The aerodynamic model was a quartz cylinder with the diameter D = 20 mm and length L= 95 mm with walls with 2 mm. The cylinder was equipped with copper circular electrodes to create an arc electric discharge on the surface, see Fig. 2.

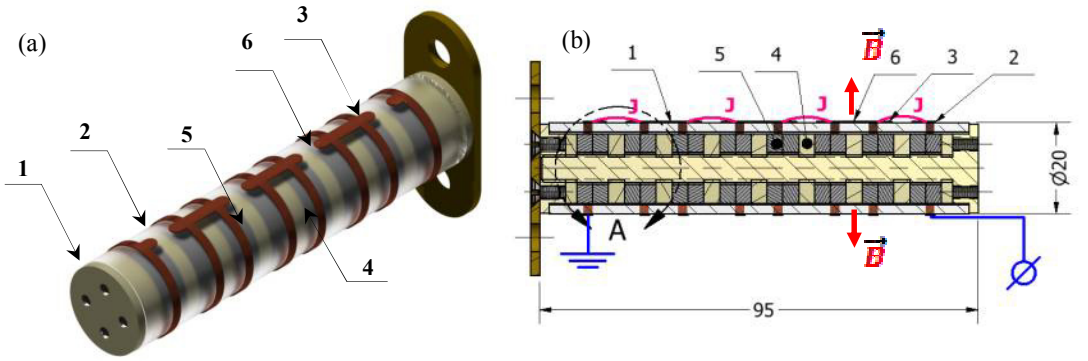

Fig. 2. (a) General view of the cylindrical model; (b) setup scheme исхемацилиндрическоймодели with multilink magneto-plasma actuator: 1- quartz tube, 2 – copperring, 3 - sharpener , 4 - dielectric nut and polyamide bolt, 5 - Nd-Fe-B magnets, 6 - connecting bridge between the electrode rings.