EFFECT OF THE PLATES SURROUNDING A CIRCULAR CYLINDER ON ITS AERODYNAMIC CHARACTERISTICS AND HEAT TRANSFER

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Currently, the problems of heat transfer enhancement and optimization of aerodynamic characteristics of heat exchange apparatus are still urgent. Industrial demands for high-efficient heating or cooling facilities have given impetus to research of new methods, according to which heat transfer grows ahead of energy consumption increase. One of the promising trends is the use of local controlled separation for heat transfer enhancement. Such a separation usually considered as a non-desirable phenomenon due to large pressure losses, when it is modeled in definite flow regions, causes heat transfer to essentially grow with an insignificant increase in the energy consumption for such flow. As shown [1-3], the actions small in scale and intensity can initiate macrochanges in the characteristics of velocity and temperature fields of medium and provide essential changes in heat transfer. In some cases, the energy spent for actions upon flow can be taken directly from the incoming flow and, hence, can enhance heat transfer with no additional energy consumption. The advantage of this approach to improving the hydrodynamic and heat transfer characteristics has been described earlier [3].

In the present work, such an approach is used for studying the possibility, how to control aerodynamic characteristics and heat transfer over the surface of a cylinder considered as a unit element of a heat exchanger. Taking into account the specific features of the heat exchanger design, the flow is acted upon by the plates that form a space near the cylinder. As known, the wake behind the investigated cylinder is characterized by developing Karman's eddy street, i.e. by the unsteady process of vortex formation responsible both for pressure deficit in the near-region of flow and for the transverse-oscillating process developing behind a considered body. The unsteady behavior of flow behind the cylinder is set already at Re=47 and is kept up to $Re=2\cdot10^5$. The structure of the near-region of the wake essentially affects the base pressure, i.e. the base drag of the streamlined body, and also the oscillating amplitude of the lift coefficient C_y. This amplitude provides the sign-variable action upon the object in the flow. In a number of cases, for example, when the separation frequency of shear layers is consistent with the natural oscillation of the body itself, the shedding vortices determine the strength quality of heat transfer facilities.

Modeling the conditions for the formation of shear layers − boundary layer in front of the separation edge or already separated shear layers ahead of a vortex wake formed by them – it is possible to vary the intensity and scale of vortices and, hence, aerodynamic characteristics and heat transfer of the streamlined body [1-5]. The laminar flow regime permits the exact modeling of flow. It provides a basis for visualizing a detailed flow pattern and the analysis of the influence of different factors in an effort to optimize their action upon changes in aerodynamic characteristics and heat transfer of a streamlined object. Related experimental research requires essentially large time and finance for an essential preliminary to measurements.

An object of investigation was represented by a unit cylinder surrounded by equal-length guide elements that were positions at an equal distance from the cylinder outer surface and the front stagnation point (Fig. 1), thus forming windows ahead of the front and rear flow stagnation points over the cylinder surface. Laminar unsteady incompressible flow past a body under study was considered in the absence of mass forces and at Reynolds number Re = 186.

Verification of the computational model was made for the case of flow around a heated circular cylinder. Computations yielded the following results: cylinder drag $C_x = 1.381$ (disagreement ~ 1.4% in comparison with the experimental value [6]); rms value of the lift coefficient C_y=0.5134 (disagreement ~6%, as compared to the predicted value [7]); the Nusselt number Nu=7.546 (disagreement ~ 9 % as against the predicted value [8]).

A length of guide plates was considered as the parameter: L = 2.24D (maximum plate length); 1.84D; 1.44D; 1.04D; 0.84D (minimum plate length). Originally, the studies of the action of the plate length at the constant coordinate of the plate rear-edge (exit window size l = 0.03D) were made. These results were used to determine an optimum length of a guide plate and then to consider the action of the angular coordinate of the leading edge of the plate. It was revealed that the plates of minimum length exert the greatest action upon an investigated system. The influence of the position of the plate leading edge on a near-wake was investigated. The minimum plate length (L=0.84D) was determined, and the angle β was varied (Fig. 1). The following configurations: β= 80º; 97º; 103º; 109º; 115º; 120º were considered.

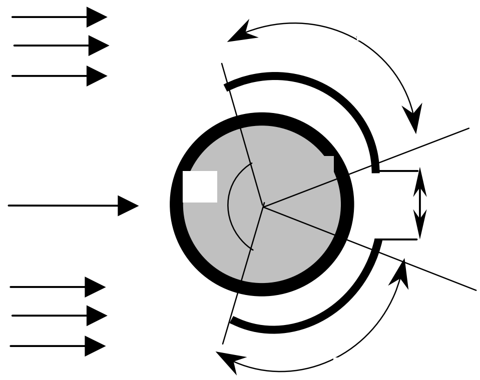

Fig.1. Scheme of a streamlined object: 1 – circular cylinder, 2 – guide plates positioned at an equal distance from the cylinder surface

Acknowledgements

The work was performed under financial support of the Belarusian Republican Foundation of Fundamental Research (project T04R-015) and Russian Foundation of Fundamental Research (projects 05-02-16184, 04-02-81005, 05-01-00162).

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