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WATER TUNNEL EXPERIMENTAL INVESTIGATION ON THE DRAG REDUCTION CHARACTERISTICS OF THE TRAVELING WAVY WALL *

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Abstract: Drag reduction experiment of the traveling wavy wall at high Reynolds number is conducted. A suit of traveling wavy wall device is developed. The drag forces of the traveling wavy wall with various wave speeds (c) are measured under different water speeds (U) in the K15 cavitation water tunnel and are compared with that of the flat plate. The results show that the mean drag force of the traveling wavy wall have decreased and then increased with oscillation frequency increasing at the same flow speed. Under different flow speeds, when traveling wave wall reached to the minimum of drag force, the corresponding the ratio of the wall motion phase speed c to flow speed U, c/U is slightly different. Within the parameters of the experiment, when c/U reaches a certain value, the drag force of the traveling wavy wall can be less than that of the flat plate. The drag reduction can be up to 42%. Furthermore, as the value of c/U increases, the traveling wavy wall can restrain the separation and improve the quality of flow field.

Key words: flow control, drag reduction, traveling wavy wall, water tunnel test

Introduction

It has been believed for a long time that swimming velocities attained by fish are remarkably high in relation to their available muscle power[1]. Fish swimming can be very instructive in disclosing mechanisms of unsteady flow control, which was raised first in the relation to swimming of live fish. Gray observed that an actively swimming dolphin only consumes one seventh of the energy needed to tow a rigid body at the same speed, and suggested that substantial drag reduction must occur in the live dolphin[2]. Then, much work has been performed to explore this problem. Important contributions by Lighthill[3,4] and Wu[5,6] have shed light on the inviscid hydrodynamics of fish-like propulsion.

It has been proposed that the travelling wave motions result in reducing drag force and increasing propulsive efficiency by restraining separation[7-9]. Experiments were undertaken to investigate viscous flow past a travelling wavy wall. Taneda and Tomonari[10] observed that the boundary layer separates at the back of the wave crest for the travelling wave phase speed being smaller than the external flow velocity, but the boundary layer does not separate for the wave phase speed being larger than the external flow velocity. Kendall[11] investigated the

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