Study on drag reduction of an enclosed rotating disk with fine spiral grooves

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Abstrak

Since the analytical result of the frictional resistance of a rotating disk has been reported by Kérrnén (l92l), many studies have been done experimentally or analytically on the characteristics of the three-dimensional boundary layer at the disk surface. Frictional resistance of an impeller of a turbo-machinery is calculated by applying that of a rotating disk flow. To improve the performance of a turbo-machinery, attempt was done by applying a drag reduction to the tlow. Thus, the drag reduction phenomena have been studied on a rotating disk in drag reducing additives (Watanabe, K., l978) or a disk with hydrophobic wall (Watanabe, K., and Ogata, S., 1997). However, the drag reducing method reported in the past remains a problem- that the degradation or the durability becomes the iitilure forthe practical application.

In this study, the experiments were carried out the measurement on the frictional moment, velocity fluctuation and protlle and flow visualization of an enclosed rotating disk in order to obtain a new passive drag reduction wall that is excellent in the durability and is practically applicable. An approximation theoretical analysis base on the momentum integral equation -also has been accounted for axial clearance ratio effects for the case of separate boundary layers onthe disk. This theory has been checked against experimental results.

lt is well known that fluid in the boundary layer ata rotating disk surface flow with keeping a flow angle (Gregory, N. et al., 1955); By considering this flow pattern, was made a disk with a new passive drag reduction wall by an etching method. The disk with many fine spiral grooves is made of aluminum. The number of the spiral grooves varying at 120, 144, 150, 155 and 160 with 0.l and 0.2 mm depth each. The clearance between the disk and the housing wall was varied at l, 3, IO, 20 and 30 mm thick.

Experimental result showed that for the close clearance l mm the moment coefficient in the turbulent region in the Reynolds number range of 4x 10" S Re S 6x 10? for the disks of l50 and |55 grooves with 0.1 and 0.2 mm depth, the drag reduction ratio was obtained about 15 %. While for the large clearance 20 mm for the disk of 144,150 and 155 grooves with 0.1mm depth in the Reynolds number range of 3.3 x to? < Re <4.0x105 the drag reduction ratio was obtained about 11 % .

The experimental results of the velocity fluctuation, velocity profile and the flow visualization also add other evidences: the fine spiral grooves control the secondary flow of the boundary layer and have the effect which delays the generation oft he local turbulence in the transition range, and reduce wall skin friction in the turbulent region.