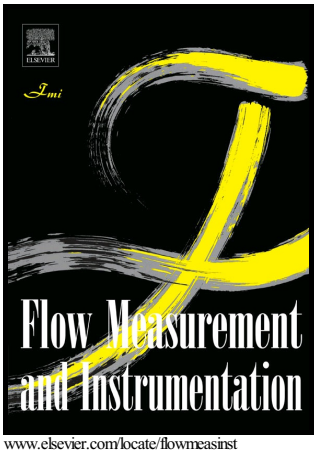
Numerical-based theoretical analysis on effects of weak fluid acceleration of free-stream due to wind-tunnel blockage on grid-generated turbulence

Hiroki Suzuki, Shinsuke Mochizuki, Yutaka Hasegawa



www.elsevier.com/locate/flowmeasinst

PII: S0955-5986(17)30376-X
DOI: https://doi.org/10.1016/j.flowmeasinst.2018.03.005
Reference: JFMI1429

To appear in: *Flow Measurement and Instrumentation*

Received date: 26 September 2017
Revised date: 26 February 2018
Accepted date: 18 March 2018

Cite this article as: Hiroki Suzuki, Shinsuke Mochizuki and Yutaka Hasegawa, Numerical-based theoretical analysis on effects of weak fluid acceleration of free-stream due to wind-tunnel blockage on grid-generated turbulence, *Flow Measurement and Instrumentation,* https://doi.org/10.1016/j.flowmeasinst.2018.03.005

Numerical-based theoretical analysis on effects of weak fluid acceleration of free-stream due to wind-tunnel blockage on grid-generated turbulence

Hiroki Suzuki*,[a], Shinsuke Mochizuki[a], Yutaka Hasegawa[b]

[a] *Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2-16-1 Tokiwadai, Ube City, Yamaguchi 755-8611, Japan.*
[b] *Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Gokiso-cho, Showa-ku, Nagoya-shi, Aichi 466-8555, Japan.*

Abstract

We present a numerical-based theoretical analysis for effects of weak fluid acceleration of free-stream due to wind-tunnel blockage on grid-generated turbulence. The increasing of displacement thickness in the developing of the boundary layers due to wind-tunnel blockage reduces the effective area of the test section of the wind tunnel. Wind tunnel blockage, which often occurs in small wind tunnels, could accelerate the freestream in the wind tunnel and thereby affect the decay of grid-generated turbulence. A previous study proposed a mathematical form that validated the blockage effects on the grid-generated turbulence by demonstrating that the fluid acceleration is too weak to affect the anisotropy of the grid-generated turbulence. The previous study used the governing equation of the two-equation model based on the $k-\epsilon$ modeling. The present study have derived a mathematical form to describe the effects of weak fluid acceleration by using the governing equation used in the previous study with simple numerical simulation. The previous mathematical form has an applicable limit of $St < 0.2$. Here, S is the streamwise nondimensional acceleration rate and is defined as $S = (dU'/dx')/(U_o/M)$, where U', x', U_o, and M are the streamwise mean velocity, the streamwise direction, the inflow velocity, and the mesh size, respectively. Moreover, t is the convection time normalized by the characteristic

*Corresponding author. E-mail; h.suzuki@yamaguchi-u.ac.jp