



Gazi Hasanuzzaman (Autor)

Experimental Investigation of Turbulent Boundary Layer with Uniform Blowing at Moderate and High Reynolds Numbers

**Experimental Investigation of
Turbulent Boundary Layer with
Uniform Blowing at Moderate and
High Reynolds Numbers**

Gazi Hasanuzzaman



Cuvillier Verlag Göttingen
Internationaler wissenschaftlicher Fachverlag

<https://cuvillier.de/de/shop/publications/8591>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen,
Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

Contents

Other Publications	xi
Contents	ixiii
List of Figures	xv
List of Tables	xxiv
1 Introduction	1
1.1 Motivation	1
1.2 Turbulent flows	3
1.3 Turbulent Boundary Layer	4
1.4 Problem statement	5
1.4.1 Physics of a blowing induced Turbulent Boundary Layer	8
1.4.2 Prandlt's mixing length hypothesis	12
1.4.3 Van Driest profile	16
1.4.4 Summary of law of the wall description	17
1.4.5 Sutherlands correction	18
1.4.6 High Reynolds number	18
1.5 Study of Coherent Structures in Turbulent Boundary Layers	20
1.6 Flow Control Technique	25
1.6.1 Super-Hydrophobic-Surface	27
1.6.2 laminar flow control	27
1.6.3 Large Eddy Break-up Devices	29
1.6.4 Ripples	29
1.6.5 Other techniques	30
1.6.6 Micro-blowing Technique	30
1.6.7 Legacy of TBL with transpiration/perforation	33
1.7 Drag reduction mechanism	43
1.8 Present experiment	45
2 Moderate Reynolds number experiment	48
2.1 Experimental setup	48
2.1.1 Wind tunnel	48
2.1.2 Flat plate geometry	49
2.1.3 Laser Doppler Anemometry (LDA)	52

CONTENTS

2.2	Processing	60
2.2.1	Data acquisition and processing	60
2.2.2	Wall shear stress	61
2.2.3	Error analysis	63
2.3	Results	65
2.3.1	Results: Standard Boundary Layer validation	65
2.3.2	Results: Integral properties	69
2.3.3	Results: Statistics	72
2.3.4	Results: performance indicator	86
2.4	Conclusion	89
3	High Reynolds number experiment	91
3.1	Introduction	91
3.2	Experimental procedure	91
3.2.1	The wind tunnel facility	93
3.2.2	Uniform blowing setup and characterization	93
3.2.3	Particle image velocimetry (PIV)	95
3.2.4	Measurement uncertainty	98
3.2.5	Convergence of data	100
3.2.6	Boundary Layer Characterization	101
3.2.7	Validation	101
3.2.8	SBL mean properties	101
3.3	Micro-blowing results and discussion	108
3.4	Conclusion	119
4	Coherent motions	121
4.1	Experimental setup	121
4.1.1	Wind tunnel instrumentation	121
4.1.2	SPIV in YZ plane	122
4.1.3	Evaluation of PIV	124
4.1.4	Image evaluation	125
4.2	Validation	127
4.3	Results	128
5	Concluding remarks	131
5.1	Moderate Reynolds number experiment	131
5.2	Spatially developed TBL at high Reynolds number	132
5.3	Coherent motions	133
5.4	Outlook	133
Bibliography		134