Contents

Acknowlegments iii

Zusammenfassung v

Abstract vii

Publications ix

Contents xi

List of Figures xv

List of Tables xix

1 Introduction and Motivation 1

2 Introduction to Reacting Turbulent Flows 3
2.1 Theoretical Concepts of Turbulence 3
2.1.1 Governing Equations of Fluid Motion 3
2.1.2 Characteristics of Turbulent Flows 5
2.1.3 Scales in Turbulent Flows 6
2.1.4 Geometries in Turbulent Flows 9
2.2 Introduction to Turbulent Combustion 10
2.2.1 Non-dimensional Numbers in Turbulent Combustion . 11
2.2.2 Models for Turbulent Combustion 13
2.3 Outline of the Thesis 15

3 Introduction to Dissipation Element Analysis 19
3.1 Introduction to Dissipation Elements 19
3.1.1 Definition of Dissipation Elements 19
3.1.2 Physical and Numerical Considerations 24
3.2 Statistics of Dissipation Element Parameters 27
3.2.1 Marginal Statistics and Scaling of mean DE Parameters 27
3.2.2 Joint Statistics 28

Bibliografische Informationen
http://d-nb.info/1221735101

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

3.2.3 DE analysis of Reacting Flows 32

4 Direct Numerical Simulations of Turbulent Reacting Flows 37
4.1 Introduction to Direct Numerical Simulations 37
4.2 Numerical Methods and Algorithms 40
4.2.1 Numerical Methods of the Non-Reacting Cases 42
4.3 Configurations and Case Descriptions 43
4.4 Turbulent Flame Analysis 46

5 Dissipation Element Based Flame Analysis of Non-Premixed Flames 51
5.1 Dissipation Element Analysis 53
5.1.1 Marginal Dissipation Element Parameter Statistics . . 55
5.1.2 Joint Dissipation Element Parameter Statistics 58
5.2 Regimes in Turbulent Non-Premixed Combustion 63
5.2.1 Local Flame Analysis 73
5.2.2 Temporal Evolution of the Combustion Regimes . . . 76

6 Dissipation Element Analysis of Turbulent Premixed Combustion 79
6.0.1 Configurations 79
6.1 DE Analysis of the Temperature Fields in Premixed Jet Flames 82
6.1.1 Marginal Statistics 82
6.1.2 Joint Statistics 88
6.2 Gradient Trajectory Analysis of the Burning Rate 96
6.2.1 Flame Structure Analysis 98
6.2.2 Correlation between Reacting Scalars and DE Parameters 103
6.2.3 Integral Statistics 108

7 Gradient Trajectory Statistics Based Modelling Applications 113
7.1 Prediction of Non-Premixed Combustion Regimes 113
7.1.1 Modelling Framework 114
7.1.2 Engine Simulations 119
7.1.3 Modelling Results 121
7.2 A New Modeling Approach for Mixture Fraction Statistics . . 124
7.2.1 Gradient Trajectory Analysis 128
7.2.2 Modeling The Mixture Fraction Structure 129
7.2.3 DE Based Modeling Approach 131
7.2.4 Model Validation and Discussion 134

8 Summary and Conclusion **137**