
Contents

Contents	i
List of Figures	v
List of Tables	xii
Nomenclature	xiii
1 Introduction	1
1.1 General context	1
1.2 Objectives and methodology	5
1.3 Thesis outline	7
References	9
2 Fundamentals of the diesel injection process	15
2.1 Introduction	15
2.2 Types of internal combustion engines	15
2.3 The diesel injector	17
2.4 The development of the diesel spray	19
2.4.1 Internal flow characterization	20
2.4.2 Combustion phases	22
2.4.3 Liquid length	23
2.4.4 Spray penetration	25
2.4.5 Ignition delay	26
2.4.6 Diffusive flame	29
2.4.7 Inter-jet spacing	31
References	34

3 Materials and methods	45
3.1 Introduction	45
3.2 Injection system	45
3.2.1 Fuel delivery system	45
3.2.2 Diesel injectors	46
3.3 Hydraulic Characterization	49
3.3.1 Rate of injection	49
3.3.2 Momentum Flux	53
3.3.3 Hydraulic coefficients	58
3.4 High-temperature and high-pressure test rig	59
3.4.1 Gas supply	60
3.5 Optical diagnostic techniques	61
3.5.1 MIE Scattering	61
3.5.2 Double-pass Schlieren	63
3.5.3 OH* chemiluminescence	67
3.5.4 Broadband chemiluminescence	69
3.5.5 Soot-DBI	70
3.6 Image processing methods	72
3.6.1 Mask construction	73
3.6.2 Background segmentation	74
3.6.3 Contour detection	76
3.6.4 Contour analysis	77
3.6.5 OH* processing: Ignition delay and lift-off length	77
3.6.6 Soot-DBI processing: KL profile	79
3.6.7 Soot-DBI processing: soot mass	83
References	85
4 Non-reactive spray development	95
4.1 Introduction	95
4.2 Test plan	96
4.3 Hydraulic characterization	97
4.3.1 Rate of injection	97
4.3.2 Momentum Flux	101
4.3.3 Hydraulic adimensional analysis	105
4.4 Spray visualization under inert conditions	106
4.4.1 Start of injection	106
4.4.2 Liquid length	107
4.4.3 Vapor spray penetration	109
4.5 Summary and conclusions	110
References	111

5 Spray ignition and lift-off length	113
5.1 Introduction	113
5.2 Test plan	113
5.3 Ignition delay	114
5.4 Initial soot appearance	118
5.5 Lift-off length	119
5.5.1 Statistical Analysis	123
5.6 Summary and conclusions	125
References	127
6 Spray combustion and soot formation	129
6.1 Introduction	129
6.2 Test plan	129
6.2.1 Optical setup considerations	129
6.2.2 Test matrix	132
6.3 KL computation through diffused back-illumination	133
6.3.1 KL maps under low temperatures	134
6.3.2 KL maps under intermediate temperatures	138
6.3.3 KL maps under high temperatures	142
6.4 Soot formation	148
6.5 Summary and conclusions	156
References	159
7 Summary and future works	163
7.1 Summary	163
7.2 Future works	166
Global Bibliography	167
A Graph Appendix	191
A.1 KL maps	192