
Contents

Contents	i
List of Figures	v
List of Tables	x
Nomenclature	xi
1 Introduction	1
1.1 Introduction	1
1.2 General context and motivations	2
1.3 Background	8
1.4 Objectives of the study	9
1.5 Thesis outline	10
References	11
2 Different solutions for pollutant emission reduction in CI engines	17
2.1 Introduction	18
2.2 Conventional diesel combustion	18
2.2.1 Combustion process	18
2.2.2 Formation of air-fuel mixture	20
2.2.3 Atomization and Evaporation	21
2.2.4 Autoignition	22
2.2.5 Diesel flame structure	23
2.2.6 Soot formation	25
2.2.7 NO _x formation	26

2.3	Role of alternative fuels in tackling pollutant emissions	27
2.3.1	Hydrotreated vegetable oil as a promising biofuel	31
2.3.2	Oxymethylene dimethyl ethers as promising e-fuels	33
2.4	Role of hardware improvements in tackling pollutant emissions	37
2.4.1	The Ducted Fuel Injection concept	38
2.5	Summary and Conclusions	43
	References	44
3	Tools and Methodology	57
3.1	Introduction	58
3.2	Fuels	58
3.3	Experimental Tools and Methodology	61
3.3.1	Optical Engine	61
3.3.2	Optical Techniques	63
3.3.2.1	Natural Luminosity	63
3.3.2.2	OH* Chemiluminiscence	63
3.3.2.3	2-Color Pyrometry	64
3.3.3	Optical Setup	66
3.3.3.1	Optical Setup A	66
3.3.3.2	Optical Setup B	68
3.3.3.3	Image Processing	71
3.3.4	DFI Design and Implementation	74
3.4	Numerical Tools and Methodology	77
3.4.1	0D/1D Modeling	77
3.4.2	Reaction Mechanism Development	77
3.4.2.1	Mechanism Reduction Techniques	78
3.4.3	Computational Fluid Dynamics Modelling	79
3.4.3.1	Navier-Stokes equations	80
3.4.3.2	Computational Domain	82
3.4.3.3	Domain Boundary Conditions	82
3.4.3.4	Mesh Configuration	84
3.4.3.5	Injector Configuration	86
3.4.3.6	Spray Model Configuration	88
3.4.3.7	Heat Transfer Model Configuration	89
3.4.3.8	Turbulence Model Configuration	90
3.4.3.9	Combustion Model Configuration	91
3.4.3.10	Emissions Model Configuration	93
3.5	Summary	94
	References	95

4 Numerical study on the potential of different fuel blends to tackle pollutant emissions	101
4.1 Introduction	102
4.2 Diesel-OME _x Blends	103
4.2.1 Fuel Definition and Mechanism development	103
4.2.1.1 Evaluation of reaction mechanisms from literature	104
4.2.1.2 PRF sub-mechanism	106
4.2.1.3 OME _x sub-mechanism	107
4.2.1.4 Mechanism Merging	109
4.2.1.5 Mechanism Validations	109
4.2.2 Analysis of blends performed through numerical simulations	117
4.2.2.1 Combustion characteristics	118
4.2.2.2 Emissions Analysis	129
4.2.2.3 Discussion	133
4.3 HVO-OME ₁ Blends	134
4.3.1 Fuel Definition and Mechanism development	134
4.3.1.1 n-Dodecane as HVO surrogate	134
4.3.1.2 n-Dodecane sub-mechanism	136
4.3.1.3 OME ₁ sub-mechanism	138
4.3.1.4 Mechanism Merging	142
4.3.1.5 Mechanism Optimization and Validations	143
4.3.2 Analysis of blends performed through numerical simulations	150
4.3.2.1 Combustion Characteristics	151
4.3.2.2 Emissions Analysis	156
4.3.2.3 Discussion	160
4.4 Summary and conclusions	161
4.4.1 Diesel-OME _x blends	161
4.4.2 HVO-OME ₁ blends	163
References	164
5 Ducted fuel injection (DFI) application applied to CI engines to reduce pollutant emissions	171
5.1 Introduction	171
5.2 Operating Conditions	172
5.3 DFI vs Free Spray	174
5.4 Parametric Evaluation of DFI geometry	178
5.4.1 Thermodynamic analysis	178

5.4.2 In-cylinder <i>KL</i> analysis	179
5.4.3 Quantification of in-cylinder <i>KL</i> reduction achieved with DFI	184
5.5 Application of fuel blends to DFI	185
5.6 Summary and conclusions	187
References	188
6 Conclusions and future works	191
6.1 Introduction	191
6.2 Conclusions	191
6.2.1 Potential of blends of different fuels to tackle pollutant emissions	193
6.2.2 Ducted fuel injection (DFI) concept applied to CI en- gines to reduce pollutant emissions	195
6.3 Future works	196
Global Bibliography	199