

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Internal combustion engines .....	2
1.2	Acoustic emissions .....	3
1.3	Objectives .....	5
1.4	Thesis outline .....	5
<b>2</b>	<b>Literature review</b>	<b>7</b>
2.1	Physics of combustion noise generation .....	7
2.2	Combustion noise in compression-ignited chambers.....	8
2.2.1	Combustion chamber resonance .....	9
2.3	Phenomenological description of the CI combustion.....	12
2.3.1	Towards lean combustion concepts.....	12
2.4	Techniques for combustion noise analysis .....	14
2.4.1	Impact on external-radiated field .....	15
2.4.2	Combustion as a source of noise .....	16
2.5	Conclusions.....	20
<b>3</b>	<b>Experimental characterization of combustion noise</b>	<b>23</b>
3.1	Experimental facilities .....	23
3.1.1	Engine for conventional Diesel combustion .....	24
3.1.2	Engine for advanced LTC combustion .....	25
3.2	Conventional Diesel combustion .....	27
3.3	Advanced LTC combustion concepts .....	34
3.4	Conclusions.....	39
3.A	Appendix: metrics for noise characterization .....	41
3.A.1	Classical method .....	41
3.A.2	Method of three-parameters .....	41
3.A.3	Methods validation .....	43

<b>4</b>	<b>Numerical model implementation</b>	<b>45</b>
4.1	Description of the numerical model .....	46
4.2	Turbulence modelling evaluation .....	49
4.3	Mesh independence study .....	52
4.4	Temporal discretization .....	55
4.5	Definition of computational domain .....	57
4.6	Initialization of the simulation .....	58
4.6.1	Effects of initial conditions .....	59
4.6.2	Simulation of multiple engine cycles .....	63
4.7	Effects of injection and combustion uncertainties .....	67
4.8	Conclusions .....	70
<b>5</b>	<b>Validation of the numerical results</b>	<b>73</b>
5.1	Methodology .....	73
5.2	Conventional Diesel combustion .....	76
5.2.1	Validation of a single operation condition .....	77
5.2.2	Validation of additional operation conditions .....	81
5.3	Gasoline Partially Premixed Combustion .....	85
5.3.1	Validation of a single operation condition .....	86
5.3.2	Validation of additional operation conditions .....	91
5.4	Conclusions .....	92
<b>6</b>	<b>Noise in conventional Diesel combustion</b>	<b>95</b>
6.1	Analysis of combustion noise origin .....	96
6.1.1	Identification of combustion noise sources .....	96
6.1.2	Effects of turbulence on combustion noise sources .....	99
6.2	Analysis of in-cylinder pressure field .....	102
6.2.1	Data preparation .....	102
6.2.2	Fourier analysis .....	104
6.2.3	Proper Orthogonal Decomposition .....	106
6.2.4	Dynamic Mode Decomposition .....	115
6.3	Conclusions .....	119
<b>7</b>	<b>Noise optimization of conventional Diesel combustion</b>	<b>123</b>
7.1	Strategies based on operating settings .....	124
7.2	Strategies based on the injector configuration .....	131
7.2.1	Frequency analysis .....	131
7.2.2	Modal decomposition analysis .....	136
7.3	Design optimization strategies .....	139
7.3.1	Simplified approach .....	141

7.3.2	Genetic algorithm optimization strategy .....	142
7.3.3	Optimization results .....	146
7.3.4	Coherence of the results .....	149
7.3.5	Acoustic analysis .....	151
7.4	Conclusions.....	157
<b>8</b>	<b>Noise in gasoline Partially Premixed Combustion</b>	<b>163</b>
8.1	Main limitations of the concept .....	164
8.2	Analysis of an extended operating range .....	166
8.3	Conventional injector optimization .....	168
8.4	Advanced injector configuration.....	178
8.4.1	Optimization methodology .....	178
8.4.2	Optimization results .....	180
8.4.3	Optimized vs. baseline comparison .....	183
8.4.4	Sensitivity of the injection settings .....	188
8.5	Conclusions.....	190
<b>9</b>	<b>Conclusions and future works</b>	<b>193</b>
9.1	Conclusions.....	193
9.1.1	Original contributions.....	193
9.1.2	Methodology findings.....	195
9.2	Future works .....	197
	<b>Bibliography</b>	<b>199</b>