

Contents

1	Introduction	1
1.1	Introduction	1
1.2	General framework	1
1.3	Diesel engines for passenger cars	3
1.4	Document structure	4
	Bibliography	6
2	Literature review and thesis approach	9
2.1	Introduction	9
2.2	Room temperature cold start	10
2.3	Ignition aids	13
2.3.1	Intake air heating	14
2.3.2	Hot spot ignition aid	14
2.4	In-cylinder conditions for low temperature cold start	16
2.5	Review of relevant results	18
2.6	Thesis approach	23
2.6.1	Literature review conclusions	23
2.6.2	Objectives of the thesis	25
2.6.3	General methodology and research development	26
	Bibliography	27
3	Tools and methodology	31
3.1	Introduction	31
3.2	Tools for experimental combustion analysis	32
3.2.1	Experimental facility	32

3.2.2	In-cylinder pressure analysis	39
3.2.3	Image acquisition and post-processing	41
3.3	Additional experimental information	43
3.3.1	Mass flow rate	44
3.3.2	Momentum flux	45
3.3.3	Non-vaporizing spray visualization	45
3.4	Modeling tools	47
3.4.1	Chemical kinetics	48
3.4.2	CFD calculations	49
3.5	Conclusions	50
	Bibliography	52
4	Cold start phenomenological description	53
4.1	Introduction	53
4.2	General description of the combustion event	55
4.2.1	Pilot combustion characteristics	60
4.3	Effect of rail pressure and total injected mass	62
4.3.1	Pilot injection	62
4.3.2	Full injection strategy	65
4.4	Synthesis: Phenomenological model of the cold start combustion process	70
4.5	Conclusions	72
	Bibliography	74
5	Influence of hardware configuration	75
5.1	Introduction	75
5.2	Influence of glow plug position relative to spray	76
5.2.1	Pilot injection	78
5.2.2	Full injection strategy	79
5.3	Influence of glow plug temperature	81
5.3.1	Glow plug surface temperature measurement	82
5.3.2	Engine results	85
5.4	Conclusions	87
	Bibliography	89

6	Influence of nozzle geometry	91
6.1	Introduction	91
6.2	Nozzle characterization results	92
6.2.1	Mass flow rate and momentum flux tests results	93
6.2.2	Non-vaporizing spray visualization results	97
6.3	Nozzle influence on pilot ignition	99
6.4	Nozzle influence on main combustion	102
6.5	Conclusions.....	104
	Bibliography	106
7	Discussion on cold start ignition mechanisms	107
7.1	Introduction	107
7.2	Study of the processes that lead to pilot ignition	108
7.2.1	Effect of local temperature	110
7.2.2	Effect of mixing process.....	112
7.3	Analysis of parametric variations	117
7.4	Conclusions.....	119
	Bibliography	121
8	Conclusions and future work	123
8.1	Conclusions.....	123
8.2	Future work	126
	Bibliography	129