

Table of Contents

Declaration	v
Acknowledgement	vi
Abstract	ix
Table of Contents	xi
List of Figures	xiv
List of Tables	xvii
Abbreviations and Symbols	xix
Chapter 1 Introduction	1
1.1 World Energy Scenario:.....	1
1.1.1 Indian Energy Scenario	2
1.2 Need for Alternative Fuel	4
1.3 Biodiesel as Diesel Engine Fuel	4
1.4 Resources of Biodiesel.....	6
1.5 NO _x Emissions	8
1.6 Emission Norms of India	9
1.7 Effect of NO _x Emission on Environment and Health	11
1.8 NO _x Mitigation Techniques	12
1.8.1 Exhaust Gas Recirculation	12
1.8.2 Water Emulsion.....	13
1.8.3 Water Injection (WI)	14
1.8.4 Fuel Additives	14
1.8.5 Selective Catalytic Reduction (SCR)	15
1.8.6 Selective Non-Catalytic Reduction (SNCR)	16
1.9 NO _x and CO Emission Reactions with Water	16
1.10 Government Policy on Biodiesel	18
1.10.1 The Vision and Goals	18
1.11 The scope of work.....	18
1.12 Organisation of Thesis	19
Chapter 2 Literature Review	21
2.1 Introduction.....	21
2.2 NO _x Mitigation Techniques	21
2.2.1 Exhaust Gas Recirculation (EGR).....	21

2.2.2 Water Emulsion	24
2.2.3 Water Injection	27
2.2.4 Fuel Additives	30
2.2.5 Selective Catalytic Reduction (SCR)	31
2.2.6 Selective Non-Catalytic Reduction (SNCR)	32
2.3 Effect of Compression Ratio and Injection Pressure.	33
2.3.1 Effect of Compression Ratio	34
2.3.2 Effect of Injection Pressure	36
2.4 Summary	38
Fuel Additives	41
2.5 Research Gap	41
2.6 Objectives	42
Chapter 3 Material and Methodology	43
3.1 Madhuca longifolia (Mahua)- a biodiesel feedstock	43
3.1.1 Preparation of Biodiesel Fuel	45
3.1.2 Madhuca Longifolia Biodiesel Blends Properties:.....	47
3.1.3 Properties of ML Biodiesel Blends	48
3.2 Experimental Set Up	49
3.2.1 Variation in Compression Ratio	52
3.2.2 Eddy Current Dynamometer	52
3.2.3 Exhaust Gas Analyzer	53
3.2.4 Smoke Meter	55
3.2.5 Water Injector	55
3.2.6 Water Pump	56
3.3 Experimental Methodology	57
3.3.1 Test procedure	57
3.3.2 Operating Instructions	60
3.3.3 Uncertainty Analysis	61
Chapter 4 Results and Discussion	62
4.1 Phase I Result and discussion	62
4.1.1 Observations and results.....	62
4.1.2 Brake Thermal Efficiency	70
4.1.3 Carbon monoxide Emission (CO)	75
4.1.4 Unburned Hydrocarbon (UHC).....	79

4.1.5 Nitrogen Oxide (NO _x) Emissions	84
4.1.6 Smoke Opacity	89
4.2 Operating Parameters for the Phase II Experimentation.....	93
4.3 Phase II Result and Discussion	94
4.3.1 Observations and Results	94
4.4 Effect of Water Injection on Exhaust Emissions	98
4.4.1 Water Injection Effect on NO _x Emission.....	98
4.4.2 Water Injection Effect on CO Emission.....	101
4.4.3 Water Injection Effect on Smoke Emission	104
4.4.4 Water Injection Effect on HC Emission.....	106
Chapter 5 Conclusion and Scope of Future Work.....	108
5.1 Conclusion	108
5.1.1 Phase -I Experimentation	108
5.1.2 Phase -II Experimentation	109
5.2 Summary of Conclusion	110
5.3 Scope of Future Work.....	110
Chapter 6 Appendix.....	112
Appendix A: Uncertainty Analysis.....	112
Appendix B: Fuel Test Report	120
Appendix C: Calibration Reports.....	121
Appendix D: Laboratory Test Report	123
Appendix E: Anti-Plagiarism Report.....	124
References.....	125
Publications	139