

CONTENTS

Title	Page No.
Certificate	
Acknowledgement	I
Abstract	II
Contents	IV
List of Figures	VIII
List of Tables	XII
Abbreviations	XII
Chapter 1. Introduction	1-33
1.1. Internal Combustion Engine	1
1.2. Function of internal combustion engine	2-6
1.3. Component of internal combustion engine	2
1.3.1 Cylinder block	2
1.3.2 Cylinder Head	2
1.3.3 Piston	3
1.3.4 Piston Rings	3
1.3.5 Connecting Rod	4
1.3.6 Gudgeon Pin	4

1.3.7 Crank Pin	4
1.3.8 Crank Shaft	5
1.3.9 Cam Shaft	5
1.3.10 Inlet Valve & Exhaust Valve	5
1.3.11 Governor	5
1.3.12 Carburetor	5
1.3.13 Fuel Pump	5
1.3.14 Spark Plug	5
1.3.15 Fuel Injector	6
1.4 Types of Piston Rings	6-9
1.4.1 Compression rings	6
1.4.2 Oil control rings	7
1.5 Types of Piston Rings Material	10-11
1.6 Piston Rings Coatings	12-15
1.7 New Development in Piston Rings Coatings	16-17
1.8 Manufacturing	17-18
1.9 Testing on Piston Rings	18-23
1.9.1 Chemical Composition	18
1.9.2 Coating Porosity	19
1.9.3 Pore Size	20
1.9.4 Microstructure and Phase distribution	20
1.9.5 Unmelted Particles and Reaction Products	21

1.9.6	Micro-cracks and Fissures	21
1.9.7	Coating Hardness	22
1.9.8	Particle and phase hardness	22
1.9.9	Running Face Porosity, Voids, Cracks, Bond Defects between Coating and Inlay Groove Land (on Inlaid Rings)	23
1.9.10	Coating Thickness	
1.10.	Types of wear of the coating	23
1.10.1	Adhesive wear of coating	24-33
1.10.2.	Abrasive wears of coating	25
1.10.3.	Surface fatigue wear of the coating	27
1.10.4.	Fretting wear of coating	29
1.10.5.	Erosive wear of coating	30
		32-32
Chapter- 2	Testing on piston rings	34-49
2.1	Microstructure Testing	34
2.2	Chemical Composition Testing (using SEM/XRD/EDS)	34-35
2.3	Mechanical Strength (Micro Hardness)	35
2.4	Adhesion Testing	36
2.5	Wear testing on the piston rings Coatings	36-49
2.5.1	Types of wear test of piston rings coating	36
2.5.2	Scratch test of piston rings coating	37
2.5.3	Slurry Abrasion Test of piston rings coating	37

2.5.4	Friction Test of thermal spray coating	38-39
2.5.5	Air Jet Erosion Test of thermal spray coating	39-40
2.5.6	Pin on Disc Test of thermal spray coating	40-49
Chapter -3 Experimental Procedure		50-78
3.1	Sample Preparation	50-53
3.2	Coating Preparation	54-66
3.2.1	Plasma Arc Spray Coating	54-63
3.2.2	Preparation of Hard Chrome Plating	63-64
3.2.3	Preparation of Gas Nitriding sample	65-66
3.3	Design of experiments	67-68
3.4	Pin on disc test	68-71
3.5	Scanning electron microscope	72-74
3.6	X -Ray diffractometer	74-75
3.7	Vickers micro hardness tester	75-77
3.8	Optical Microscope	77-78
Chapter -4 Result & Discussion		79-115
4.1	Coating characterization	79-81
4.2.	Wear rate of the coatings	81-90
4.2.1	Wear rate of air plasma spray coating with tungsten carbide, En-31 and nickel pin	81-84

4.2.2	Wear rate of Hard Chrome plating coating with tungsten carbide, En-31 and nickel pin	84-87
4.2.3.	Wear rate of Gas Nitriding with tungsten carbide pin, En-31 and Nickel pin	87-90
4.3.	Coefficient of friction (CoF) of the coatings	91-102
4.3.1	Coefficient of friction of the plasma sprayed coating with Tungsten carbide, En-31and nickel pin	91-93
4.3.2.	Coefficient of friction (CoF) of the hard chrome coating with En-31,tungsten carbide and nickel pin at different loading Condition	94-97
4.3.3	Coefficient of friction (CoF) of the gas nitride plate with En-31, tungsten carbide and nickel pin at different loading condition	98-102
4.4	Wear mechanism	103-115
4.4.1	Wear mechanism of plasma coating with En-31, tungsten carbide & nickel pin	103-108
4.4.2	Wear mechanism of chrome plating with En-31, tungsten carbide & nickel pin	108-111
4.4.3.	Wear mechanism of gas nitriding with En-31, tungsten carbide & nickel Pin and nickel pin at different loading condition:	111-115
Chapter -5	Conclusion	116-117
Chapter -6	Future Scope of this study	118

