
TABLE OF CONTENTS

| Content | Page no. |
|--|-----------------|
| Preface | x |
| Acknowledgement | xiii |
| List of Figures | xv |
| List of abbreviations/symbols | xxiv |
| Chapter 1: Introduction | 1-9 |
| 1.1. Introduction | 1 |
| 1.2. Aim and objective of work | 7 |
| 1.3. Organization of thesis | 9 |
| Chapter 2: Literature Review | 10-51 |
| 2.1. Carbon Fibers | 10 |
| 2.2. Tribological behaviour of C/C composites | 12 |
| 2.2.1. Processing of C/C composites | 13 |
| 2.2.2. Carbon-Carbon composites as braking material | 14 |
| 2.2.3. Wear and friction behaviour of C/C composites | 16 |
| 2.2.3.1. Effect of nanoadditives on friction and wear performance | 19 |
| 2.2.3.2. Effect of friction film on wear and coefficient of friction | 21 |
| 2.2.3.3. Short time oxidation behaviour | 23 |
| 2.2.3.4. Effect of in situ grown carbon nanofibres (CNF) on oxidation behaviour | 23 |
| 2.2.3.5. Effect of functionally graded coating on oxidation | 24 |
| 2.2.3.6. Effect of ultra high temperature ceramic coating on oxidation behaviour | 25 |
| 2.2.3.7. Effect of SiC coating on oxidative wear | 26 |
| 2.2.3.8. Effect of wet and corrosive environment on friction | 27 |
| 2.2.3.9. Characterization of surface grooves induced by friction of C/C composites | 29 |
| 2.2.3.10. Effect of carbonization rate | 30 |

| | |
|---|-------|
| 2.2.4. Wear and friction behavior of C/C-SiC composites | 31 |
| 2.2.4.1. Processing of C/C – SiC composites | 32 |
| 2.2.4.2. Tribological behaviour of C/C – SiC composites | 34 |
| 2.2.4.3. Effect of pyrolytic carbon content on tribological properties of C/C- SiC composites | 38 |
| 2.2.4.4. Effect of porosity and SiC contents on the tribological properties of C/C–SiC composites | 40 |
| 2.2.4.5. Effect of braking pressure and braking speed on tribological properties | 42 |
| 2.2.4.6. Tribological performance under dry and wet conditions | 45 |
| 2.2.4.7. Effect of graphitization of C/C preform on tribological properties of C/C – SiC composites | 47 |
| 2.2.4.8. Effect of C/C composite and C/C – SiC composite as counterface material | 49 |
| | |
| Chapter 3: Tribological behaviour under dry environment | 52-87 |
| | |
| 3.1. Introduction | 52 |
| 3.2. Materials and Synthesis | 54 |
| 3.3. Sliding Wear Tests | 56 |
| 3.3.1. Unidirectional Sliding | 56 |
| 3.3.2. Reciprocating Sliding | 59 |
| 3.3.3. Wear Mechanisms | 60 |
| | |
| 3.4. Scanning Electron Microscopy | 61 |
| 3.5. Results and Discussion | 61 |
| 3.5.1. Unidirectional Sliding | 61 |
| 3.5.1.1. Friction response | 61 |
| 3.5.1.2. Wear behaviour | 65 |
| 3.5.1.3. Discussion | 68 |
| | |
| 3.5.2. Reciprocating Sliding | 75 |
| 3.5.2.1. Friction response | 75 |
| 3.5.2.2. Wear Behaviour | 78 |
| 3.5.2.3. Discussion | 80 |

| | |
|--|---------|
| 3.5.3. Conclusion | 85 |
| 3.5.3.1. Unidirectional Sliding | 85 |
| 3.5.3.2. Reciprocating Sliding | 87 |
| | |
| Chapter 4: Tribological behaviour under brake oil environment | 88-121 |
| 4.1. Introduction | 88 |
| 4.2 Materials and Synthesis | 89 |
| 4.3 Brake oil absorption | 89 |
| 4.4 Sliding wear tests | 90 |
| 4.5 Scanning Electron Microscopy | 90 |
| 4.6 Results and Discussion | 91 |
| 4.6.1. Unidirectional Sliding | 91 |
| 4.6.1.1. Decay rate of friction coefficient in brake oil condition | 91 |
| 4.6.1.2. Friction Response | 92 |
| 4.6.1.3. Wear Behaviour | 96 |
| 4.6.1.4. Discussion | 99 |
| | |
| 4.6.2. Reciprocating Sliding | 107 |
| 4.6.2.1 Friction response | 107 |
| 4.6.2.2. Wear behaviour | 111 |
| 4.6.2.2 Discussion | 112 |
| | |
| 4.7. Conclusion | 119 |
| 4.7.1. Unidirectional Sliding | 119 |
| 4.7.2. Reciprocating Sliding | 121 |
| | |
| Chapter 5: Tribological behaviour under freezing environment | 122-151 |
| 5.1. Introduction | 122 |
| 5.2. Materials and Synthesis | 122 |
| 5.3. Freezing Conditions | 123 |
| 5.4. Sliding wear tests | 123 |
| 5.5. Scanning Electron Microscopy | 123 |

| | |
|--|---------|
| 5.6. Results and Discussions | 123 |
| 5.6.1. Unidirectional Sliding | 123 |
| 5.6.1.1. Friction Response | 123 |
| 5.6.1.2. Wear Behaviour | 127 |
| 5.6.1.3. Discussion | 129 |
| 5.6.2. Reciprocating Sliding | 142 |
| 5.6.2.1. Friction Response | 142 |
| 5.6.2.2. Wear Behaviour | 144 |
| 5.6.2.3. Discussion | 145 |
| 5.6.3. Conclusion | 149 |
| 5.6.3.1. Unidirectional Sliding | 149 |
| 5.6.3.2. Reciprocating sliding | 150 |
| Chapter 6: Reciprocating Sliding Tribology in Self and Complementary Pair | 152-168 |
| 6.1. Introduction | 152 |
| 6.2. Materials and Synthesis | 152 |
| 6.3. Reciprocating wear testing | 152 |
| 6.4. Scanning electron microscopy | 153 |
| 6.5. Results | 154 |
| 6.5.1. Variation of friction coefficient and wear loss with load in case of normal/parallel orientation combination of laminates | 154 |
| 6.5.2. Variation of friction coefficient and wear loss with load in case of parallel/parallel orientation combination of laminates | 157 |
| 6.5.3. Discussion | 160 |
| 6.6. Conclusion | 167 |
| Chapter 7: Comparison | 169-178 |
| 7.1. Comparison of unidirectional and reciprocating sliding | 169 |
| 7.1.1. Dry Environment | 169 |
| 7.1.2. Brake Oil Environment | 171 |
| 7.1.3. Freezing Environment | 172 |

| | |
|--|---------|
| 7.2. Comparison of dry, oil, and freezing environment | 174 |
| 7.2.1. Unidirectional Sliding | 174 |
| 7.2.2. Reciprocating Sliding | 176 |
| 7.2.3. Discussion | 177 |
| Chapter 8: Concluding Remarks | 179-180 |
| Chapter 9: Mathematical Model | 181-193 |
| 9.1. Introduction | 181 |
| 9.2. Formulation of equations | 183 |
| 9.3. Validation and discussion | 190 |
| 9.4. Conclusion | 193 |
| Chapter 9: Future Scope | 194 |
| References | |
| List of Publications | |

PREFACE
