<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>SCR Systems for High-Speed Engines</td>
<td>38</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Small Ship Applications</td>
<td>39</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Rail Applications</td>
<td>39</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Gensets</td>
<td>40</td>
</tr>
<tr>
<td>2.4</td>
<td>Medium and Low-Speed Engines</td>
<td>42</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Fuels and Sulfur</td>
<td>42</td>
</tr>
<tr>
<td>2.4.2</td>
<td>SCR Technology for Marine Applications</td>
<td>45</td>
</tr>
<tr>
<td>2.4.3</td>
<td>Low-Speed Engine Genset</td>
<td>45</td>
</tr>
<tr>
<td>2.5</td>
<td>Combined Systems</td>
<td>47</td>
</tr>
<tr>
<td>2.5.1</td>
<td>DPF + SCR</td>
<td>47</td>
</tr>
<tr>
<td>2.5.2</td>
<td>Combination of DeNoxation and DeSulfurization</td>
<td>51</td>
</tr>
<tr>
<td>2.6</td>
<td>System Integration</td>
<td>51</td>
</tr>
<tr>
<td>2.6.1</td>
<td>Reductant Supply</td>
<td>51</td>
</tr>
<tr>
<td>2.6.2</td>
<td>Canning Concepts</td>
<td>55</td>
</tr>
<tr>
<td>2.7</td>
<td>Control Strategies</td>
<td>56</td>
</tr>
<tr>
<td>2.8</td>
<td>Outlook</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>59</td>
</tr>
</tbody>
</table>

**Part II  Catalysts**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Vanadia-Based Catalysts for Mobile SCR</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Jonas Jansson</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Introduction</td>
<td>65</td>
</tr>
<tr>
<td>3.2</td>
<td>Legislation</td>
<td>66</td>
</tr>
<tr>
<td>3.3</td>
<td>Main SCR Reactions</td>
<td>67</td>
</tr>
<tr>
<td>3.4</td>
<td>Urea Injection</td>
<td>68</td>
</tr>
<tr>
<td>3.5</td>
<td>Properties of Vanadia SCR Catalyst</td>
<td>68</td>
</tr>
<tr>
<td>3.6</td>
<td>Reaction Mechanism</td>
<td>71</td>
</tr>
<tr>
<td>3.7</td>
<td>Function/Principle Design</td>
<td>73</td>
</tr>
<tr>
<td>3.8</td>
<td>Dimensioning of SCR System</td>
<td>76</td>
</tr>
<tr>
<td>3.9</td>
<td>Effect of NO₂</td>
<td>81</td>
</tr>
<tr>
<td>3.10</td>
<td>Aging of Vanadia SCR Catalyst</td>
<td>83</td>
</tr>
<tr>
<td>3.10.1</td>
<td>Thermal Aging</td>
<td>83</td>
</tr>
<tr>
<td>3.10.2</td>
<td>Impact of Sulfur</td>
<td>85</td>
</tr>
<tr>
<td>3.10.3</td>
<td>Alkali Metals and Alkaline Earth Metals</td>
<td>87</td>
</tr>
<tr>
<td>3.10.4</td>
<td>Oil Poisons</td>
<td>88</td>
</tr>
<tr>
<td>3.10.5</td>
<td>Hydrocarbons</td>
<td>90</td>
</tr>
<tr>
<td>3.10.6</td>
<td>Arsenic and Lead</td>
<td>91</td>
</tr>
<tr>
<td>3.10.7</td>
<td>Biofuel</td>
<td>91</td>
</tr>
<tr>
<td>3.10.8</td>
<td>In-use Aging Evaluation</td>
<td>92</td>
</tr>
<tr>
<td>3.11</td>
<td>Summary and Conclusions</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>93</td>
</tr>
</tbody>
</table>
4 Fe-Zeolite Functionality, Durability, and Deactivation
Mechanisms in the Selective Catalytic Reduction (SCR)
of NO\textsubscript{x} with Ammonia ........................................ 97
Todd J. Toops, Josh A. Pihl and William P. Partridge
4.1 Introduction .................................................. 97
4.2 Experimental Considerations in Evaluating
and Aging Catalysts ............................................ 99
4.3 Fe-Zeolite NO\textsubscript{x} Reduction Characteristics ............... 104
4.4 Durability, Aging Techniques, and Deactivation Mechanism
Affecting Performance ......................................... 111
4.5 Summary .................................................... 118
References ....................................................... 119

5 Cu/Zeolite SCR Catalysts for Automotive Diesel NO\textsubscript{x}
Emission Control ............................................. 123
Hai-Ying Chen
5.1 Introduction .................................................. 123
5.2 Chemistry and Functionality of Cu/Zeolite SCR Catalysts . 124
5.3 Deactivation Mechanisms of Cu/Zeolite SCR Catalysts ....... 126
  5.3.1 Hydrothermal Deactivation ................................ 126
  5.3.2 Hydrocarbon Storage, Inhibition, and Poisoning ......... 132
  5.3.3 Sulfur Poisoning ........................................... 133
  5.3.4 Urea and Urea Deposit Related Catalyst
      Deactivation ................................................ 133
  5.3.5 Chemical Poisoning ...................................... 134
5.4 Development of Small-Pore Zeolite Supported
Cu SCR Catalysts ............................................. 135
5.5 Investigation on the Superior Hydrothermal Stability
of Small-Pore Zeolite Supported Cu SCR Catalyst .......... 140
5.6 Investigation on the Active Cu Sites in Small-Pore
Zeolite Supported Cu SCR Catalysts ....................... 142
5.7 Summary .................................................... 143
References ....................................................... 144

6 Low-Temperature Selective Catalytic Reduction (SCR) of NO\textsubscript{x}
with NH\textsubscript{3} Over Zeolites and Metal Oxide-Based Catalysts
and Recent Developments of H\textsubscript{2}-SCR ..................... 149
Gongshin Qi, Lifeng Wang and Ralph T. Yang
6.1 Ammonia-SCR .................................................. 149
  6.1.1 Introduction ................................................ 149
  6.1.2 Catalysts and Mechanistic Aspects
      of the Low-Temperature Ammonia-SCR ............... 151
<table>
<thead>
<tr>
<th>Part III  Mechanistic Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>7  Active Sites for Selective Catalytic Reduction</td>
</tr>
<tr>
<td>Wolfgang Grünert</td>
</tr>
<tr>
<td>7.1 Introduction</td>
</tr>
<tr>
<td>7.2 Strategies and Methods for the Identification of Active Sites</td>
</tr>
<tr>
<td>7.3 Supported Vanadia Catalysts</td>
</tr>
<tr>
<td>7.4 Zeolite-Based Catalysts</td>
</tr>
<tr>
<td>7.4.1 Fe Zeolites</td>
</tr>
<tr>
<td>7.4.2 Cu Zeolites</td>
</tr>
<tr>
<td>7.5 Recent Catalyst Development</td>
</tr>
<tr>
<td>7.6 Concluding Remarks</td>
</tr>
<tr>
<td>References</td>
</tr>
</tbody>
</table>

| 8  Mechanistic Aspect of NO–NH₃–O₂ Reacting System | 221 |
| Masaoki Iwasaki |
| 8.1 Introduction | 221 |
| 8.2 Steady-State Reaction Analysis | 221 |
| 8.2.1 NH₃/NO/O₂, NH₃/O₂, and NO/O₂ Reactions | 221 |
| 8.2.2 Apparent Activation Energy | 223 |
| 8.2.3 Apparent Reaction Orders | 224 |
| 8.2.4 Relationship with NO Oxidation Activity | 227 |
| 8.2.5 Effect of Coexisting Gases and Poisoning | 230 |
| 8.3 Transient Reaction Analysis | 233 |
| 8.3.1 Periodic NH₃ Supply | 233 |
| 8.3.2 NO Pulse Reaction | 237 |
| 8.3.3 In Situ FT-IR Analysis | 238 |
| 8.4 Reaction Mechanisms | 240 |
| 8.4.1 Vanadium-Based Catalysts | 240 |
| 8.4.2 Fe- or Cu-Exchanged Zeolite Catalysts | 242 |
| 8.5 Conclusions | 244 |
| References | 244 |

<p>| 9  The Role of NO₂ in the NH₃–SCR Catalytic Chemistry | 247 |
| Enrico Tronconi and Isabella Nova |
| 9.1 Introduction | 247 |
| 9.2 Experimental | 248 |</p>
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.3  Surface Storage of NOx</td>
<td>249</td>
</tr>
<tr>
<td>9.3.1 NO2 Adsorption/Desorption</td>
<td>249</td>
</tr>
<tr>
<td>9.3.2 FTIR in Situ Study of NO2 Adsorption</td>
<td>250</td>
</tr>
<tr>
<td>9.3.3 Effect of the Catalyst Redox State on NO2 Adsorption</td>
<td>251</td>
</tr>
<tr>
<td>9.4  The Role of Surface Nitrates in the Fast SCR Mechanism</td>
<td>253</td>
</tr>
<tr>
<td>9.4.1 NH3 + NOx Temperature Programmed Reaction (TPR) Runs</td>
<td>253</td>
</tr>
<tr>
<td>9.4.2 Role of Nitrates in the NO/NO2–NH3 SCR Mechanism</td>
<td>255</td>
</tr>
<tr>
<td>9.5  Mechanistic Studies by Transient Response Methods</td>
<td>255</td>
</tr>
<tr>
<td>9.5.1 Reactivity of Surface Nitrates with NO and with NH3</td>
<td>256</td>
</tr>
<tr>
<td>9.5.2 The Role of Nitrites</td>
<td>257</td>
</tr>
<tr>
<td>9.5.3 Overall Mechanistic Scheme</td>
<td>258</td>
</tr>
<tr>
<td>9.5.4 Ammonia Blocking of Nitrates Reduction</td>
<td>259</td>
</tr>
<tr>
<td>9.5.5 Considerations on the Red-ox Nature of the NH3–SCR Mechanisms</td>
<td>260</td>
</tr>
<tr>
<td>9.5.6 Higher Temperatures: The NO2–SCR Reaction</td>
<td>261</td>
</tr>
<tr>
<td>9.5.7 Selectivity Issues: The Formation of NH4NO3, N2O</td>
<td>262</td>
</tr>
<tr>
<td>9.6  Feeding Nitrates: The Enhanced SCR Reaction</td>
<td>263</td>
</tr>
<tr>
<td>9.6.1 The Boosting Action of Ammonium Nitrate</td>
<td>263</td>
</tr>
<tr>
<td>9.6.2 Analysis of the Enhanced SCR Chemistry</td>
<td>267</td>
</tr>
<tr>
<td>9.7  Summary and Conclusions</td>
<td>268</td>
</tr>
<tr>
<td>References</td>
<td>269</td>
</tr>
</tbody>
</table>

## Part IV Reaction Kinetics

10  Kinetics of NH3-SCR Reactions Over

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2O5–WO3/TiO2 Catalyst</td>
<td>273</td>
</tr>
<tr>
<td>Isabella Nova and Enrico Tronconi</td>
<td></td>
</tr>
<tr>
<td>10.1  Introduction</td>
<td>273</td>
</tr>
<tr>
<td>10.2  Methods</td>
<td>274</td>
</tr>
<tr>
<td>10.2.1 Experimental Rig and Procedures</td>
<td>274</td>
</tr>
<tr>
<td>10.2.2 Mathematical Model of the Microreactor for Kinetic Tests</td>
<td>275</td>
</tr>
<tr>
<td>10.3  NH3/O2 Reacting System</td>
<td>276</td>
</tr>
<tr>
<td>10.4  NH3–NO/O2 Reacting System</td>
<td>282</td>
</tr>
<tr>
<td>10.5  NH3–NO/NO2 Reacting System</td>
<td>294</td>
</tr>
<tr>
<td>10.6  Conclusions</td>
<td>308</td>
</tr>
<tr>
<td>References</td>
<td>308</td>
</tr>
</tbody>
</table>
11 Lean NOx Reduction by NH₃ on Fe-Exchanged Zeolite and Layered Fe/Cu Zeolite Catalysts: Mechanisms, Kinetics, and Transport Effects ............................................. 311
Michael P. Harold and Pranit Metkar
11.1 Introduction ................................................................. 311
11.2 Reaction System Performance Features .................................. 312
  11.2.1 NO Oxidation and NO₂ Decomposition ......................... 315
  11.2.2 NH₃ Oxidation .................................................. 316
  11.2.3 Selective Catalytic Reduction of NOx .......................... 317
11.3 Kinetics and Mechanistic Considerations ................................ 324
  11.3.1 NO Oxidation .................................................. 325
  11.3.2 Standard SCR Reaction ...................................... 331
  11.3.3 Ammonia Inhibition .......................................... 333
  11.3.4 Selective Catalytic Reaction with NO and NO₂ .......... 334
11.4 Reaction and Transport Interactions .................................... 343
11.5 Reactor Modeling Developments ........................................ 348
11.6 Concluding Remarks .................................................... 353
References ................................................................. 354

12 Kinetic Modeling of Ammonia SCR for Cu-Zeolite Catalysts ...... 357
Louise Olsson
12.1 Introduction ................................................................. 357
12.2 Kinetic Models for Ammonia and Water Storage Over Cu-Zeolites ................................................................. 358
  12.2.1 Global Kinetic Model for Ammonia Storage and Desorption ......................... 361
  12.2.2 Detailed Kinetic Model for Ammonia and Water Storage ......................... 362
12.3 Kinetic Models for Ammonia Oxidation Over Cu-Zeolites ... 364
  12.3.1 Global Kinetic Model for Ammonia Oxidation .......................... 364
  12.3.2 Detailed Kinetic Model for Ammonia Oxidation ...................... 364
12.4 Kinetic Models for NOₓ Storage and NO Oxidation Over Cu-Zeolites ................. 365
  12.4.1 Detailed Kinetic Model for NO Oxidation ......................... 365
  12.4.2 Global Kinetic Model for NO Oxidation .......................... 369
12.5 Kinetic Models for SCR Reactions Over Cu-Zeolites ......... 371
  12.5.1 Global Kinetic Models for SCR Over Cu-Zeolites ... 371
  12.5.2 Detailed Kinetic Models for SCR Over Cu-Zeolites ...... 376
12.6 Conclusions ............................................................... 381
References ................................................................. 381
Part V Modeling and Control

13 SCR Reactor Models for Flow-Through and Wall-Flow Converters

Dimitrios Karamitros and Grigorios Koltsakis

13.1 Introduction ................................................. 385
13.2 Fundamentals of Flow-Through Catalyst Modeling .... 386
  13.2.1 Balance Equations ................................. 387
  13.2.2 Washcoat Internal Diffusion Modeling .......... 389
  13.2.3 Multidimensional Model Extension .......... 391
13.3 Reaction Modeling ....................................... 392
  13.3.1 Adsorption Model ............................... 392
  13.3.2 de-NO\textsubscript{x} Reactions ...................... 394
  13.3.3 Parameter Calibration ............................. 397
13.4 Importance of Washcoat Diffusion Modeling .......... 397
  13.4.1 Experimental Results ................................ 398
  13.4.2 Simulation Study and Effective Diffusivity Investigation 398
13.5 From Lab Reactor Tests to Real-World System Modeling 400
  13.5.1 Overview of Model Parameterization Approaches 400
  13.5.2 Microreactor and Monolith Reactor Tests ........ 400
  13.5.3 Real-World Full-Scale Applications ............. 402
13.6 Fundamentals of SCR on DPF Modeling ................. 403
  13.6.1 Wall-Flow Filter Model .......................... 403
  13.6.2 SCR Kinetic Model and Soot Oxidation Kinetics 406
  13.6.3 Wall-Flow Versus Flow-Through Monoliths ........ 407
  13.6.4 Interactions Between Soot and de-NO\textsubscript{x} Activity 408
13.7 Integrated Exhaust System Modeling .................... 412
  13.7.1 Model-Based DPF + SCR System Optimization 413
  13.7.2 Combined LNT-SCR Concepts ....................... 416
  13.7.3 Combined SCR-ASC Concept ....................... 418
13.8 Conclusion: Perspectives .................................. 419
References ......................................................... 422

14 Diesel Engine SCR Systems: Modeling, Measurements, and Control

Ming-Feng Hsieh and Junmin Wang

14.1 Introduction ............................................... 425
14.2 SCR Control-Oriented Modeling .......................... 426
  14.2.1 Introduction ......................................... 426
  14.2.2 Main SCR Reactions ................................ 426
  14.2.3 Control-Oriented SCR Model ....................... 427
14.3 SCR Sensing and Estimation Systems ................... 430
  14.3.1 NO\textsubscript{x} Sensor NH\textsubscript{3} Cross-Sensitivity .... 431
14.3.2 SCR Catalyst Ammonia Coverage
Ratio Estimation ........................................ 437
14.4 SCR Control ........................................ 441
  14.4.1 Control-Oriented SCR Model .................... 442
  14.4.2 Controller Design and Architecture .......... 443
  14.4.3 Experimental Setup ............................ 444
  14.4.4 Experimental Results of US06 Test Cycle ..... 446
14.5 Conclusions ......................................... 448
References ............................................... 449

Part VI Ammonia Supply

15 DEF Systems and Aftertreatment Architecture Considerations .... 455
  Ryan Floyd, Levin Michael and Zafar Shaikh
  15.1 Role of Engine and Dosing Calibration ............. 459
  15.2 Overview of Injection Technology and Spray Quality ... 461
  15.3 Overview of SCR System Mixing Devices .......... 467
  15.4 SCR System Mixing Devices: Ford Practical Example ... 471
  15.5 Aftertreatment Architecture ....................... 474
  15.6 Deposit Mitigation: Practical Example ............. 479
  15.7 Concluding Remarks ................................ 483
References ............................................... 483

16 Ammonia Storage and Release in SCR Systems
for Mobile Applications .................................. 485
  Daniel Peitz, Andreas Bernhard and Oliver Kröcher
  16.1 Introduction ........................................ 485
  16.2 Urea as Ammonia Precursor Compound .............. 486
    16.2.1 Solid Urea .................................... 486
    16.2.2 Urea Solution ................................ 487
    16.2.3 Urea Thermolysis and Evaporation .......... 487
    16.2.4 Urea Decomposition Byproducts and Catalyst Deactivation .................................. 489
    16.2.5 Catalytic Urea Decomposition ............... 491
  16.3 Alternative Ammonia Precursor Compounds .......... 493
    16.3.1 Cyanuric Acid .................................. 493
    16.3.2 Ammonium Formate ............................ 494
    16.3.3 Ammonium Carbamate .......................... 495
    16.3.4 Metal Ammine Chlorides ...................... 496
    16.3.5 Methanamide ................................... 498
    16.3.6 Guanidinium Salts ............................. 499
    16.3.7 Catalytic Decomposition of Alternative NH₃ Precursor Compounds .......................... 499
References ............................................... 501
Gianluca Montenegro and Angelo Onorati
17.1 Introduction ................................................. 507
17.2 1D Models for the Prediction of Gas Flows .................. 508
17.2.1 Modeling the Thermal Aspects ............................ 510
17.2.2 Thermal and Hydrolytic Decomposition of Urea ....... 516
17.2.3 Kinetic Model ............................................. 517
17.3 Multidimensional Models .................................... 521
17.3.1 Governing Equations ................................. 521
17.3.2 Modeling the UWS Injection ............................. 526
17.3.3 Modeling the Formation of Liquid Film ................. 532
17.3.4 Discretization of Source Terms and Equations ......... 535
17.3.5 Examples of CFD Application ........................... 538
References .......................................................... 547

Part VII Integrated Systems

18 Dual-Layer Ammonia Slip Catalysts for Automotive SCR Exhaust Gas Aftertreatment: An Experimental and Modeling Study ......................................................... 553
Isabella Nova, Massimo Colombo, Enrico Tronconi,
Volker Schmeißer, Brigitte Bandl-Konrad and Lisa Zimmermann
18.1 Introduction ..................................................... 554
18.2 Methods ....................................................... 556
18.2.1 Experimental .............................................. 557
18.2.2 Modeling ................................................... 558
18.3 Derivation and Validation of the SCR Model ............... 561
18.3.1 Reaction Network and Kinetic Scheme
Over the SCR Component ............................................. 561
18.3.2 Kinetic Fit .................................................. 566
18.3.3 Model Validation .......................................... 567
18.4 Derivation and Validation of the PGM Catalyst Model .... 567
18.4.1 Reaction Network and Kinetic Scheme
Over the PGM Component ........................................... 567
18.4.2 Model Fit ................................................. 573
18.4.3 Model Validation ........................................... 573
18.5 Analysis and Modeling of SCR/PGM Interactions .......... 575
18.5.1 Experimental Study of SCR/PGM Interactions ...... 575
18.5.2 Predictive Simulations of the SCR/PGM
Combined Systems ................................................. 577
18.6 Modeling of Dual-Layer Monolith ASC .......................... 579
  18.6.1 Development of a Dual-Layer Monolith Model .......... 579
  18.6.2 Validation of the Dual-Layer Monolith ASC Model .... 581
18.7 Conclusions ......................................................... 583
References ............................................................... 584

19 NSR–SCR Combined Systems: Production and Use of Ammonia ........................................ 587
Fabien Can, Xavier Courtois and Daniel Duprez
19.1 Introduction ......................................................... 587
19.2 NH₃ Emission from NSR Catalysts ......................... 588
  19.2.1 The NSR Process ............................................... 588
  19.2.2 Ammonia Formation Pathways ............................ 589
  19.2.3 Influencing Parameters/Ammonia Reactivity ........... 591
  19.2.4 Conclusion ....................................................... 596
19.3 Coupling of NOx Trap and NH₃–SCR Catalysts .......... 596
  19.3.1 Emergence and Development of the NSR–SCR Coupling Concept ........................................... 596
  19.3.2 Coupling of Pt Catalysts with Zeolites ................. 598
  19.3.3 Coupling of Pt(RhPd)/BaO/Al₂O₃ with Cu–Zeolite Catalysts .................................................. 598
  19.3.4 Coupling of Pt(RhPd)/BaO/Al₂O₃ with Fe–Zeolite Catalysts .................................................. 603
  19.3.5 Other Systems Including Tungsten-Based Catalysts ......................................................... 606
19.4 Selective Catalytic Reduction of NOx by Ammonia (NH₃–SCR) ...................................................... 608
  19.4.1 Mechanistic Aspects of the SCR Reaction ............... 608
  19.4.2 Effect of Zeolite Framework ................................ 610
  19.4.3 Role of Acidic Sites .......................................... 611
  19.4.4 Active Sites and Performances of Cu–Zeolite, Fe–Zeolite, and Other Systems in NH₃–SCR .......... 612
19.5 Conclusion and Perspective ...................................... 614
References ............................................................... 615

20 Integration of SCR Functionality into Diesel Particulate Filters .................................................. 623
Thorsten Boger
20.1 Introduction ......................................................... 624
20.2 Diesel Particulate Filter Technologies ....................... 626
  20.2.1 Diesel Particulate Filter Designs and Materials ....... 626
  20.2.2 Catalyst Coatings for Diesel Particulate Filters ....... 629
20.3 Performance Considerations for SCR Integrated Diesel Particulate Filters
   20.3.1 Pressure Drop and Permeability .......................... 630
   20.3.2 Filtration ........................................... 636
   20.3.3 Filter Regeneration, Thermal Management, and Durability ........ 640
   20.3.4 DeNOx Efficiency ........................................ 643
20.4 Modeling of SCR Integrated Particulate Filters .................. 645
20.5 Application Examples ...................................... 648
   20.5.1 Light Duty ............................................. 648
   20.5.2 Heavy Duty ............................................. 650
20.6 Summary ....................................................... 651
References ......................................................... 652

Part VIII Case Histories

21 Development of the 2010 Ford Diesel Truck Catalyst System .... 659
Christine Lambert and Giovanni Cavataio
21.1 Introduction .................................................. 660
21.2 Early Research at Ford on Lean NOx Control for Diesel Vehicles ........ 661
21.3 Ford’s Research Program on a Prototype Light-Duty Diesel Truck ........ 663
   21.3.1 SCR System Design ....................................... 663
   21.3.2 DOC Development for SCR Systems .................. 664
   21.3.3 SCR Catalyst Formulations ............................. 666
   21.3.4 Vehicle System Results ................................. 666
21.4 Migration of Research into a Production Vehicle Program ........ 668
   21.4.1 Vehicle Program Needs for Lean NOx Control .......... 668
   21.4.2 Catalyst and System Design Options .................. 669
21.5 Development Challenges Associated with SCR Catalyst Systems ........ 670
   21.5.1 Thermal Stability of the DOC ........................... 670
   21.5.2 Thermal Stability of the SCR Catalyst .................. 671
   21.5.3 Ammonia Storage Management ............................ 674
   21.5.4 HC Poisoning/Coking of Zeolitic SCR Catalysts ....... 676
   21.5.5 Precious Metal Poisoning ............................... 679
   21.5.6 Sulfur Effects on Catalysts ............................. 681
   21.5.7 Urea Injection/Mixing ................................... 682
   21.5.8 Urea Specifications and Refill .......................... 682
21.6 Environmental Impact of Medium-Duty Diesels:
Current and Future .................................................. 683
  21.6.1 NOx Emissions ................................................. 683
  21.6.2 Greenhouse Gas Footprint (CO₂, CH₄, N₂O) .......... 684
  21.6.3 Use of Base Metals, Pd Rich Catalysts ......... 684

21.7 Conclusion ...................................................... 686
References .......................................................... 687

22 Model-Based Approaches to Exhaust Aftertreatment
System Development .................................................... 691
Michel Weibel, Volker Schmeißer and Frank Hofmann

  22.1 Introduction ...................................................... 692
  22.2 Modeling of the Exhaust Gas Aftertreatment System .... 693
    22.2.1 Total System Simulation ................................. 693
    22.2.2 Model Structure ........................................... 694
    22.2.3 Kinetics and Parameterization ......................... 695
  22.3 Simulation Methods in the Development Process ......... 696
    22.3.1 Demands of the Development Process ................. 696
    22.3.2 The Virtual Testbench Concept ....................... 697
    22.3.3 Development of an AdBlue® Dosing Control Strategy 697
  22.4 Outlook: On-board Model-Based SCR Control .......... 704
  22.5 Summary ........................................................ 705
References .......................................................... 706

About the Editors .................................................... 709

Index ................................................................. 711
Urea-SCR Technology for deNOx After Treatment of Diesel Exhausts
Nova, I.; Tronconi, E. (Eds.)
2014, XX, 716 p. 411 illus., 292 illus. in color., Hardcover
ISBN: 978-1-4899-8070-0