Content

Preface

Abbreviation and symbols

Zusammenfassung ..... i-xii

1. Introduction 1

1.1 Fireside corrosion limits the efficiency of coal-fired power plants 1

1.2 Fireside corrosion in biomass and waste combustion systems .. 3

1.3 Fireside corrosion on waterwall 5

1.4 Objects and research methods in this study 5

2. State-of-the-Art Research of Fireside Corrosion in Coal and Biomass Boilers 7

2.1 Kinetics and thermodynamics of fireside corrosion 7

2.1.1 Corrosion kinetics 7

2.1.2 Thermodynamics of high temperature corrosion 8

2.1.3 Oxidation, sulphidation and chlorination in thermodynamic point of view 9

2.2 Deposit formation and its influence on fireside corrosion 14

2.2.1 The formation and transport of fly ash 14

2.2.2 Deposit growth and strength development in deposit 17

2.2.3 Hot corrosion 18

2.2.4 Waterwall corrosion 22

2.3 Chlorine-induced corrosion in biomass or waste combustion facilities 27

2.3.1 Corrosion mechanisms 27

2.3.2 The influence of chlorine on sulphur-induced corrosion 32

2.3.3 The effect of SO_2 on reducing chloride deposition 33

2.3.4 Conclusion 34

2.4 Materials 35

2.4.1 Evolution of boiler materials 35

2.4.2 Corrosion resistance 39

2.4.3 High temperature strength of boiler materials 42

2.5 Measurement Technique 45

2.5.1 Laboratory measurements 45

2.5.2 Field studies 46

3. Experimental Techniques 49

3.1 Description of experimental methods 49

3.2 Combustion tests 50

3.3 Laboratory corrosion tests 53

3.4 Laboratory analysis 55

4. Laboratory Investigation 61

4.1 Mechanisms of chlorine-induced corrosion 61

4.1.1 Corrosion mechanism in slight reducing environment 62

4.1.2 Corrosion mechanism in oxidizing environment 63

4.1.3 Conclusion kinetics 72

4.1.4 Influence of HCl and H_2O on corrosion rate 76

4.1.5 Conclusion 77

4.2 Combined influences of gas and deposits on chlorine corrosion 80

4.2.1 Test conditions 80

4.2.2 The change of ash deposition with time in reducing and oxidizing atmospheres 83

4.2.3 The influences of ash deposit on corrosion rate in reducing, oxidizing and oxidizing-sulphating atmosphere 86

4.2.4 Corrosion resistance of advanced boiler materials 95

4.2.5 Conclusion 103

5. Combustion Test 106

5.1 Co-combustion of lignite with paper sludge and compost waste 106

5.1.1 Fuel characteristics and test program 106

5.1.2 Test results 108

5.1.3 Conclusion 117

5.2 Co-combustion of South Africa coal with olive husk 117

5.2.1 Fuel characteristics and test program 117

5.2.2 Test results 120

5.2.3 Conclusion 129

6. Thermodynamic Calculation of Combustion Products of Coal-Straw Fuel Blends **131**

6.1 Calculation method and fuel data 131

6.2 Calculation results 133

6.3 Experimental results 140

6.4 Conclusion 144

7. Discussion **146**

7.1 Conclusion 146

7.2 Outlook of future research activities 152

Literature **154**