Table of Contents

Abstract I

Kurzfassung IV

Table of Contents VII

Nomenclature X

1 Introduction 1

1.1 Coal combustion in power generation in response to environmental issues 1

1.2 Flameless oxidation, development and potential in pulverised coal combustion 3

1.3 Tasks and objectives of the present work 7

1.4 Approach and outline of the present work 9

2 State of the art 11

2.1 Flame dilution technology in pulverised coal combustion 11

2.1.1 Flameless oxidation of pulverised coal under pressurised conditions 12

2.1.2 History of study on the HiTAC of pulverised coal 13

2.2 Nitrogen oxides in pulverised coal combustion 15

2.2.1 Major NO formation processes in pulverised coal combustion 16

2.2.2 NO reduction processes in pulverised coal combustion 18

2.2.3 NO_x emissions control technologies in pulverised coal-fired utility boilers 20

3 Experimental setup 23

3.1 Bench-scale combustion test facility 23

3.2 Pilot-scale combustion test facility 24

3.3 Measurement equipment, calibration and error discussion 26

3.3.1 Standard flue gas analysis 26

3.3.2 Volatile nitrogenous components analysis 27

3.3.3 Coal and ash sample analyses 30

3.4 Fuels 30

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

4 Study on pulverised coal flameless oxidation 32

4.1 Burnout 35

4.1.1 Carbon burnout 35

4.1.2 Coal burnout 38

4.2 NO formation 41

4.2.1 Thermal and fuel NO in air-staged conditions 42

4.2.1.1 Total volatile fuel-N 43

4.2.1.2 Influence of the air ratio at the burner on fuel NO 46

4.2.2 Thermal and fuel NO in unstaged conditions 47

4.2.2.1 Influence of the furnace wall temperature on fuel NO 49

4.3 NO_x emissions 51

4.3.1 Influence of the burner air ratio 51

4.3.2 Influence of the secondary air velocity 55

5 Optimisation of the near burner aerodynamics 58

5.1 Burner-port (quarl) 59

5.2 Burner air injection scheme 63

5.2.1 Secondary air nozzles pitch circle diameter 63

5.2.2 Number of secondary air nozzles 65

5.3 Trade-off between NO_x and unburned carbon 67

6 Scale-up of the PC-FLOX™ burner 72

6.1 Scale-up methodology 72

6.2 Numerical investigations 76

6.2.1 Modelling of the pilot-scale PC-FLOX™ burner 78

6.3 Pilot-scale PC-FLOX™ burner design 83

7 Demonstration of the pilot-scale PC-FLOX™ burner 86

7.1 Experimental trials with the Lausitz lignite 86

7.1.1 Continuous measurements 87

7.1.2 Detailed in-flame measurements along the furnace axis 89

7.2 Experimental trials with the El Cerrejon bituminous coal 95

7.2.1 Continuous measurements 95

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

7.2.2 Detailed in-flame measurements along the furnace axis 98
7.2.3 Detailed in-flame measurements along the furnace plane 103
7.2.4 Effect of air staging on PC-FLOX^{TM} combustion 110

8 Conclusion and outlook 112

8.1 Conclusion 112

8.2 Outlook 116

9 References 118

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.