

A.N. HAYHURST – PUBLICATIONS

The number of each paper gives the order of its chronological appearance

I. IONISATION IN FLAMES, ENGINE EXHAUSTS, etc

1. A.N. Hayhurst and T.M. Sugden, "Non-equilibrium ionization in flames and magnetohydrodynamic power generation". *Aeronautical Research Council*, 1962, 24,040, C.F.605, pp. 1-8.
2. A.N. Hayhurst and T.M. Sugden, "Non-equilibrium ionization in flames", *Institute of Electrical Engineers, Conference Report Series*, 1963, 4, 126 – 127.
3. A.N. Hayhurst and T.M. Sugden, "The ionization processes associated with metallic additives in flame gases". *IUPAC XX International Congress (Symposium on Low Temperature Plasmas)*, Moscow, 1965, (published by I.U.P.A.C.), 1-35.
8. A.N. Hayhurst and P.J. Padley, "Mass spectrometric observations of ions in flow discharges". *Transactions of the Faraday Society*, 1967, 63, 1620-1630.
50. A.N. Hayhurst and D.B. Kittelson, "The positive and negative ions in oxy-acetylene flames". *Combustion and Flame*, 1978, 31, 37-51.
58. A.N. Hayhurst and H.R.N. Jones, "Chemi-ionization in oxyacetylene flames". *Nature*, 1982, 296, 61-63 and 1982, 300, 200.
63. A.N. Hayhurst, "Ions in Combustion", *Institution of Electrical Engineers, Colloquium Digest*, No. 40, paper No. 3 (3 pp.), 1984.
69. N. Collings, F.J. Doyle III, A.N. Hayhurst and D.B. Kittelson, "Ionisation in the exhaust of a spark ignition engine", *Twenty first Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, 1986, Poster No. 71.
78. N.C. Collings, F.J. Doyle III, A.N. Hayhurst, D.B. Kittelson and D. Williams, "Charged species in the exhaust of a spark ignition engine, as studied with Langmuir probes and a mass spectrometer", *Combustion Science and Technology*, 1988, 62, 31-59.
95. S.D.T. Axford, W. Cai, A.N. Hayhurst and N. Collings, "Chemi-ionisation produced by the catalytic combustion of a hydrocarbon", *Combustion and Flame*, 1991, 87, 211-216.
116. S.D.T. Axford and A.N. Hayhurst, "Ionisation in premixed fuel-lean flames of H₂, O₂ and N₂, Part 1 - Naturally Occurring Positive Ions", *J. Chem. Soc., Faraday Transactions*, 1995, 91, 827-833.
117. S.D.T. Axford and A.N. Hayhurst, "Ionisation in premixed fuel-lean flames of H₂, O₂ and N₂, Part 2 - Ions from alkali-metal additives", *J. Chem. Soc., Faraday Transactions.*, 1995, 91, 835-841.
261. H.R.N. Jones and A.N. Hayhurst, "Measurements of the concentrations of positive and negative ions along premixed fuel-rich flames of methane and oxygen", *Combustion and Flame*, 2016, 166, 86 – 97.

II. MASS SPECTROMETRY OF FLAMES AND ASSOCIATED SAMPLING PROBLEMS

4. A.N. Hayhurst and T.M. Sugden, "Mass spectrometry of flames". *Proceedings of The Royal Society, A*, 1966, 293, 36-50.

5. **P.F. Knewstubb, A.N. Hayhurst and N.R. Telford**, "Ions of low mass number in hydrocarbon flames". *Nature*, 1966, 212, 504.
16. **A.N. Hayhurst, F.R.G. Mitchell, and N.R. Telford**, "A quadrupole mass filter designed for flame ionization studies". *International Journal of Mass Spectrometry and Ion Physics*, 1971, 7, 177-187.
30. **A.N. Hayhurst**, "Mass spectrometric sampling of combustion plasmas", *I.E.E.E., Transactions on Plasma Science*, 1974, 2, 115-122.
39. **A.N. Hayhurst and N.R. Telford**, "Mass spectrometric sampling of ions from atmospheric pressure flames I: Characteristics and calibration of the sampling system". *Combustion and Flame*, 1977, 28, 67-80.
40. **A.N. Hayhurst, D.B. Kittelson and N.R. Telford**, "Mass spectrometric sampling of ions from atmospheric pressure flames II: Aerodynamic disturbances of a flame by the sampling system". *Combustion and Flame*, 1977, 28, 123-136.
41. **A.N. Hayhurst and D.B. Kittelson**, "Mass spectrometric sampling of ions from atmospheric pressure flames III: Boundary layer and other cooling of the sample". *Combustion and Flame*, 1977, 28, 137-143.
89. **S.D.T. Axford and A.N. Hayhurst**, "The sampling of ions from an atmospheric-pressure flame into a vacuum chamber", *Bull. Soc. Chim. Belge*, 1990, 99, 451-459.
101. **A.N. Hayhurst**, "The mass spectrometric sampling of ions from atmospheric pressure flames as exemplified by the reactions of OH⁻ and O₂⁻ in O₂-rich flames", *Pure and Applied Chemistry*, 1993, 65, 285-295.
120. **A.N. Hayhurst and H.R.N. Jones**, "The operation of a quadrupole mass filter with the d.c. voltage removed", *Int. J. Mass Spec. Ion Proc.*, 1995, 148, L29 - L33.
123. **A.N. Hayhurst and S. Taylor**, "Problems encountered when continuously sampling species from a flame into a mass spectrometer : a case study involving some positive ions from a rich flame of acetylene and oxygen", *Joint Meeting of the Portugese, British, Spanish and Swedish Sections of The Combustion Institute, Madeira*, 1996, p. 2.6.1 - 2.6.4.
162. **J. Guo, J.M. Goodings, A. N. Hayhurst and S.G. Taylor**, "A simple method for measuring positive ion concentrations in flames and the calibration of a nebulizer/atomizer", *Combustion and Flame*, 2003, 133, 335 – 343.
253. **A.N. Hayhurst**, "Mass spectrometric sampling of a flame", *Combustion, Explosion and Shock Waves*, 2012, 48, 516 – 525, translated from *Fizika Goreniya I Vzryva*, 2012, 48, 27 – 38 (in Russian).

III. MASS TRANSFER AND DIFFUSION AT HIGH TEMPERATURES

10. **A.F. Ashton and A.N. Hayhurst**, "Flame photometric determinations of diffusion coefficients, Part 1 - Experimental and theoretical considerations". *Transactions of the Faraday Society*, 1970, 66, 824-832.
11. **A.F. Ashton and A.N. Hayhurst**, "Flame photometric determinations of diffusion coefficients, Part 2 - Results for sodium". *Transactions of the Faraday Society*, 1970, 66, 833-842.
12. **A.N. Hayhurst and N.R. Telford**, "Diffusional effects in premixed laminar flames of hydrogen, oxygen and nitrogen". *Combustion and Flame*, 1970, 14, 303-312.
15. **A.F. Ashton and A.N. Hayhurst**, "Flame photometric determinations of diffusion coefficients, Part 3 - Results for nitric oxide". *Transactions of the Faraday Society*, 1971, 67, 2348-2353.

22. **A.F. Ashton and A.N. Hayhurst**, "Flame photometric determinations of diffusion coefficients, Part 4 - Results for lithium, potassium, rubidium and caesium". *J. Chem. Soc., Faraday Transactions I*, 1973, 69, 652-659.
25. **A.F. Ashton and A.N. Hayhurst**, "Measurements of the diffusion coefficients of alkali metal additives in atmospheric pressure flames from 1920 to 2520 K". *Combustion Institute European Symposium*, 1973, ed. F.J. Weinberg (Academic Press, 1973), pp. 735-740. (ISBN 0 12 742350 8).
34. **A.F. Ashton and A.N. Hayhurst**, "Measurements of the diffusion coefficients of trace additives (the alkaline earths and copper) in atmospheric pressure flames from 1900 to 2520 K", *2nd European Combustion Symposium*, 1975, 171-176.
37. **A.F. Ashton and A.N. Hayhurst**, "Flame photometric determinations of diffusion coefficients, Part 5 - Results for Ca(OH)_2 , Sr(OH)_2 , Ba(OH)_2 and Cu". *J. Chem. Soc., Faraday Transactions I*, 1976, 72, 208-215.
51. **A.N. Hayhurst and M.J. Springett**, "Flame photometric determinations of diffusion coefficients, Part 6 - Results for carbon monoxide and free atoms of bromine, iodine and thallium", *J. Chem. Soc., Faraday Transactions I*, 1978, 74, 715-719.
148. **A.N. Hayhurst**, "The mass transfer coefficient for oxygen reacting with a carbon particle in a fluidised or packed bed", *Combustion and Flame*, 2000, 121, 679 - 688.
157. **A.N. Hayhurst and M.S. Parmar**, "Measurement of the Mass Transfer Coefficient and Sherwood Number for Carbon Spheres Burning in a Bubbling Fluidised Bed", *Combustion and Flame*, 2002, 130, 361 – 375.
198. **J.S. Dennis, A.N. Hayhurst and S.A. Scott**, "The combustion of large particles of char in bubbling fluidized beds: The dependence of Sherwood number and the rate of burning on particle diameter", *Combustion and Flame*, 2006, 147, 185 – 194.

IV. THERMODYNAMICS AND KINETICS OF IONIC REACTIONS IN FLAMES

6. **A.N. Hayhurst and N.R. Telford**, "Reactions of the hydroxonium ion with metal atoms in flames". *Nature*, 1966, 212, 813-814.
7. **A.N. Hayhurst and T.M. Sugden**, "Effect of halogens on the ionization in alkali - laden hydrogen and acetylene flames". Part 2: Results and derived rate constants, *Transactions of the Faraday Society*, 1967, 63, 1375-1384.
9. **A.N. Hayhurst**, "Alkali-metal ions and their monohydrates in the gas phase". *"The Alkali Metals" (Special Publication No. 22)*, London, The Chemical Society, 1967, 139-146.
13. **A.N. Hayhurst and N.R. Telford**, "Charge exchange reactions of H_3O^+ with metals in flames". *Transactions of the Faraday Society*, 1970, 66, 2784-2793.
17. **A.N. Hayhurst and N.R. Telford**, "Kinetics of thermal ionization of alkali metals in flames". *J. Chem. Soc., Faraday Transactions I*, 1972, 68, 237-248.
18. **A.N. Hayhurst and N.R. Telford**, "Kinetics and heats of the reactions $\text{H} + \text{H} + \text{OH} = \text{H}_3\text{O}^+ + \text{e}^-$ in flames". *Nature, Phys. Sci.*, 1972, 58, 114-115.
19. **A.N. Hayhurst and D.B. Kittelson**, "Kinetics of the gas phase reactions $\text{MOH}^+ + \text{e}^- = \text{M} + \text{OH}$ or $\text{MO} + \text{H}$, with M being Ca or Sr". *J. Chem. Soc., Chemical Communications*, 1972, 422-423.
21. **A.N. Hayhurst and D.B. Kittelson**, "A determination of the ionisation potentials of CaOH and SrOH ". *Combustion and Flame*, 1972, 19, 306-308.

23. **A.F. Ashton and A.N. Hayhurst**, "Kinetics of collisional ionization of alkali metal atoms and recombination of electrons with alkali metal ions in flames". *Combustion and Flame*, 1973, 21, 69-75.
24. **A.N. Hayhurst and D.B. Kittelson**, "Mechanism and kinetics of production and recombination of ions arising from additives of alkaline earth elements in flames of $\text{H}_2/\text{O}_2/\text{N}_2$ ". *Combustion Institute European Symposium 1973*, ed. F.J. Weinberg (Academic Press, 1973) pp. 261-265. (ISBN 0 12 742350 8).
29. **A.N. Hayhurst and D.B. Kittelson**, "Ionization of alkaline earth additives in hydrogen flames II. Kinetics of production and recombination of ions". *Proceedings of The Royal Society, A*, 1974, 338, 175-195.
31. **A.N. Hayhurst and N.R. Telford**, "The kinetics of dissociative recombination of free electrons with hydronium ions in premixed flames". *J. Chem. Soc., Faraday Transactions I*, 1974, 70, 1999-2010.
33. **A.N. Hayhurst and N.R. Telford**, "The proton affinity of water and the kinetics of production of H_3O^+ in flames of H_2 , O_2 and N_2 ". *J. Chem. Soc., Faraday Transactions I*, 1975, 71, 1352-1362.
36. **N.A. Burdett and A.N. Hayhurst**, "The rate constants for ion-ion recombination in $\text{H}_3\text{O}^+ + \text{X}^- \rightarrow \text{HX} + \text{H}_2\text{O}$ with $\text{X} = \text{Cl}, \text{Br}$ or I , from studies in $\text{H}_2/\text{O}_2/\text{N}_2$ flames". *2nd European Combustion Symposium*, 1975, 55-59.
38. **N.A. Burdett and A.N. Hayhurst**, "Cross-sections for gas phase ion-ion recombination in $\text{H}_3\text{O}^+ + \text{X}^- \rightarrow \text{HX} + \text{H}_2\text{O}$ for $\text{X} = \text{Cl}, \text{Br}$ or I ". *J. Chem. Soc., Faraday Transactions I*, 1976, 72, 245-256.
45. **N.A. Burdett and A.N. Hayhurst**, "The rate coefficients of the gas-phase reactions: $\text{K}^+ + \text{Cl}^- \rightarrow \text{K} + \text{Cl}$ and $\text{K}^+ + \text{Cl}^- + \text{M} \rightarrow \text{KCl} + \text{M}$ from measurements in atmospheric pressure flames". *Chemical Physics Letters*, 1977, 48, 95-99.
48. **N.A. Burdett and A.N. Hayhurst**, "The kinetics of gas-phase electron-ion recombination by $\text{NO}^+ + \text{e}^- \rightarrow \text{N} + \text{O}$ from measurements in flames". *J. Chem. Soc., Faraday Transactions I*, 1978, 74, 53-62.
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53. **N.A. Burdett and A.N. Hayhurst**, "Determination of the rate coefficients of $\text{A} + \text{X} \rightarrow \text{A}^+ + \text{X}^-$ and $\text{AX} + \text{M} \rightarrow \text{A}^+ + \text{X}^- + \text{M}$, where A is a metal atom, X a halogen atom and M a flame species". *Philosophical Transactions of The Royal Society*, 1979, 290A, 299-325.
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55. **J.M. Goodings and A.N. Hayhurst**, "Kinetics of electron attachment to oxygen and water in flames". *Nature*, 1979, 281, 204-206.
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119. **J.M. Goodings, P.M. Patterson and A.N. Hayhurst**, "A mass-spectrometric study of the production and recombination of BaOH^+ ions and free electrons from barium added to flames of $\text{H}_2 + \text{O}_2 + \text{Ar}$ ", *J. Chem. Soc., Faraday Transactions.*, 1995, 91, 2257-2267.
122. **C.J. Butler and A.N. Hayhurst**, "Kinetics of dissociative recombination of H_3O^+ ions with free electrons in flames", *J. Chem. Soc., Faraday Transactions.*, 1996, 92, 707 - 714.
130. **S.D.T. Axford and A.N. Hayhurst**, "Mass spectrometric sampling of negative ions from flames of hydrogen and oxygen: the kinetics of electron attachment and detachment in hot mixtures of H_2O , O_2 , OH and HO_2 ", *Proceedings of The Royal Society, A*, 1996, 452, 1007 - 1033.
131. **S.D.T. Axford and A.N. Hayhurst**, "The stabilities of the gas-phase ions CO_3^- and HCO_3^- , together with the kinetics of both their production and removal in O_2 -rich flames of $\text{H}_2 + \text{O}_2 + \text{N}_2$ ", *Proceedings of The Royal Society, A*, 1996, 452, 1035 - 1054.
136. **C.J. Butler and A.N. Hayhurst**, "Reactions of H_3O^+ ions with free atoms of copper and molecules of CuOH in gaseous flames", *J. Chem. Soc., Faraday Transactions*, 1997, 93, 1497-1506.
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V. CHEMICAL REACTIONS IN SUPERSONIC FLOWS

14. **A.N. Hayhurst and N.R. Telford**, "The occurrence of chemical reactions in supersonic expansions of a gas into a vacuum and its relation to mass spectrometric sampling". *Proceedings of the Royal Society, A*, 1971, 322, 483-507.
35. **N.A. Burdett and A.N. Hayhurst**, "The kinetics of formation of chloride ions in atmospheric pressure flames by $\text{HCl} + \text{e}^- \rightarrow \text{H} + \text{Cl}^-$ ". *Proceedings of The Combustion Institute*, 1975, 15, 979-990.
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52. **N.A. Burdett and A.N. Hayhurst**, "Mass spectrometric sampling of ions from atmospheric pressure flames IV: Scattering processes in molecular beams from supersonic expansions". *Combustion and Flame*, 1979, 34, 119-134.

VI. MEASUREMENTS OF FREE RADICALS IN FLAMES

20. **A.N. Hayhurst and D.B. Kittelson**, "The measurement of hydrogen atom concentrations in flames". *Nature, Phys. Sci.*, 1972, 235, 136-137.
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28. **A.N. Hayhurst and D.B. Kittelson**, "Ionisation of alkaline earth additives in hydrogen flames I. Hydrogen atom concentrations and ion stabilities". *Proceedings of The Royal Society, A*, 1974, 338, 155-173.
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102. **C.J. Butler and A.N. Hayhurst**, "Measurement of the maximum concentration of CH radicals from observations of ionic abundances in a flame", *Proc. Anglo-German Combustion Symposium*, British Section of the Combustion Institute, Cambridge, 1993, 180-183. (ISBN 0 9520350 0 6).
142. **C.J. Butler and A.N. Hayhurst**, "Measurements of the concentrations of free hydrogen atoms in flames from observations of ions: Correlation of the burning velocities with concentrations of free hydrogen atoms", *Combustion and Flame*, 1998, 115, 241-252.

VII. THE POLLUTANT NO_x: ITS PRODUCTION IN AND REMOVAL FROM FLAMES AND FLUIDISED BED COMBUSTORS

32. **A.N. Hayhurst and H.A.G. McLean**, "Mechanism for producing NO from nitrogen in flames". *Nature*, 1974, 251, 303-305.
43. **A.N. Hayhurst and I.M. Vince**, "Production of "prompt" nitric oxide and decomposition of hydrocarbons in flames". *Nature*, 1977, 266, 524-525.
44. **N.A. Burdett and A.N. Hayhurst**, "Some observations of the NO^+ ion and neutral NO in atmospheric pressure flames of acetylene and hydrogen". *Proceedings of The Combustion Institute*, 1977, 16, 903-915.
56. **A.N. Hayhurst and I.M. Vince**, "Nitric oxide formation from N_2 in flames: the importance of "prompt" NO". *Progress in Energy and Combustion Science*, 1980, 6, 35-51.
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61. **A.N. Hayhurst and I.M. Vince**, "Mechanism of "prompt" NO formation in flames". *Oxidation Communications*, 1983, 4, 147-161.
66. **A.N. Hayhurst and I.M.P.A. Cabrita**, "The appearance and consumption of the cyanide pool in flames in the presence of hydrocarbons and nitrogenous compounds", *Archivum Combustionis*, 1985, 5, 349-364.

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94. **D. Allen and A.N. Hayhurst**, "The reduction of nitric oxide by carbon monoxide in a fluidised bed", *Proceedings Inst. Energy 5th International Fluidised Combustion Conference*, 1991, Adam Hilger, Bristol, p. 221-230.
100. **A.N. Hayhurst and A.D. Lawrence**, "The production of nitric oxide during the combustion of volatiles when coal burns in a fluidised bed", *Archivum Combustionis*, 1992, 12, 17-43.
103. **A.N. Hayhurst and A.D. Lawrence**, "The effect of CaO on the formation and destruction of NO_x and N₂O in fluidised beds between 700 and 900°C", *Proc. Anglo-German Combustion Symposium*, British Section of the Combustion Institute, Cambridge, 1993, 515-518. (ISBN 0 9520350 0 6).
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139. **A.N. Hayhurst and E.M. Hutchinson**, "Evidence for a new way of producing NO via NNH in fuel-rich flames at atmospheric pressure", *Combustion and Flame*, 1998, 114, 274 - 279.
210. **A.F Barker, D. Hart and A.N. Hayhurst**, "The production of nitric oxide during the pyrolysis of small particles of a coal in a hot (electrically heated) bed of sand fluidized by nitrogen", *Proceedings of the European Combustion Meeting 2007*, Paper 11-7, 6 pp., Crete, 2007.
225. **A.F. Barker, D. Hart and A.N. Hayhurst**, "Kinetics of production of nitric oxide during the pyrolysis of small particles of coal in a hot (electrically heated) bed of sand fluidised by pure nitrogen", *J. Energy Institute*, 2008, 81, 125 - 130.
259. **D. Allen and A.N. Hayhurst**, "The chemical reactions of nitric oxide with solid carbon and catalytically with gaseous carbon monoxide", *Fuel*, 2015, 142, 260 - 267.
260. **D. Allen and A.N. Hayhurst**, "The effect of CaO on emissions of nitric oxide from a fluidized bed combustor", *Fuel*, 2015, 158, 898 - 907.

VIII. HEAT TRANSFER AT HIGH TEMPERATURES

42. **A.N. Hayhurst and D.B. Kittelson**, "Heat and mass transfer considerations in the use of electrically heated thermocouples of iridium versus an iridium/rhodium alloy in atmospheric pressure flames". *Combustion and Flame*, 1977, 28, 301-317.
57. **N.A. Burdett and A.N. Hayhurst**, "Hydration of gas-phase ions and the measurement of boundary-layer cooling during flame sampling into a mass spectrometer". *J. Chem. Soc., Faraday Transactions I*, 1982, 78, 2997-3007.
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146. **W.R. Paterson and A.N. Hayhurst**, "Mass or heat transfer from a sphere to a flowing fluid", *Chemical Engineering Science*, 2000, 55, 1925 - 1927.
156. **M.S. Parmar and A.N. Hayhurst**, "The heat transfer coefficient for a freely moving sphere in a bubbling fluidised bed", *Chemical Engineering Science*, 2002, 57, 3485 - 3494.
170. **A.P. Collier, A.N. Hayhurst, J.L. Richardson and S.A. Scott**, "The heat transfer coefficient between a particle and a bed (packed or fluidised) of much larger particles", *Chemical Engineering Science*, 2004, 59, 4613 - 4620.

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195. **J – S. Chern and A.N. Hayhurst**, "A model for the devolatilization of a coal particle sufficiently large to be controlled by heat transfer", *Combustion and Flame*, 2006, 146, 553 – 571.

IX. COMBUSTION OF GASEOUS MIXTURES IN FLUIDISED BEDS

59. **J.S. Dennis, A.N. Hayhurst and I.G. Mackley**, "The ignition and combustion of propane/air mixtures in a fluidised bed". *Proceedings of The Combustion Institute*, 1982, 19, 1205-1212.

86. **A.N. Hayhurst and R.F. Tucker**, "The combustion of carbon monoxide in a two-zone fluidized bed", *Combustion and Flame*, 1990, 79, 175-189.

144. **A.N. Hayhurst, J.J. John and R.J. Wazacz**, "The combustion of propane and air as catalysed by platinum in a fluidised bed of hot sand", *Proceedings of The Combustion Institute*, 1998, 27, 3111 - 3118.

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189. **D.R. Chadeesingh and A.N. Hayhurst**, "The combustion of mixtures of methane and air in bubbling fluidized beds of hot sand", *19th International Conference on Fluidized Bed Combustion*, Vienna, 2006, 288 – 297 (ISBN 3-200-00645-5).

233. **J. Baron, E.M. Bulewicz, S. Kandefer, M. Pilawska, W. Żukowski and A.N. Hayhurst**, "Combustion of hydrogen in a bubbling fluidized bed", *Combust. Flame*, 2009, 156, 975 – 984.

256. **D.R. Chadeesingh and A.N. Hayhurst**, "The combustion of a fuel-rich mixture of methane and air in a bubbling fluidized bed of silica sand at 700°C and also with particles of Fe₂O₃ or Fe present", *Fuel*, 2014, 127, 169 – 177.

X. REMOVAL OF SULPHUR OXIDES AND H₂S FROM FLUIDISED BED COMBUSTORS

62. **J.S. Dennis and A.N. Hayhurst**, "The effect of pressure on the kinetics and extent of sulphation of calcareous materials in fluidised beds". *Eighth International Symposium on Chemical Reaction Engineering*, 1984, Institution of Chemical Engineers, Symp. Ser. No. 87, 61-68.

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