Stanford

Reginald Mitchell

Professor of Mechanical Engineering, Emeritus

CONTACT INFORMATION

- **Administrative Contact**

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Bio

BIO

Professor Mitchell's primary area of research is concerned with characterizing the physical and chemical processes that occur during the combustion and gasification of pulverized coal and biomass. Coals of interest range in rank from lignite to bituminous and biomass materials include yard waste, field and seed crop residues, lumber mill waste, fruit and nut crop residues, and municipal solid waste. Experimental and modeling studies are concerned with char reactivity to oxygen, carbon dioxide and steam, carbon deactivation during conversion, and char particle surface area evolution and mode of conversion during mass loss.

Mitchell’s most recent research has been focused on topics that will enable the development of coal and biomass conversion technologies that facilitate CO2 capture. Recent studies have involved characterizing coal and biomass conversion rates in supercritical water environments, acquiring the understanding needed to develop chemical looping combustion technology for applications to coals and biomass materials, and developing fuel cells that use coal or biomass as the fuel source. Studies concerned with characterizing coal/biomass blends during combustion and gasification processes are also underway.

Professor Mitchell retired from Stanford University in July 2020, after having served over 29 years as a professor in the Mechanical Engineering Department.

ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Mechanical Engineering
- Affiliate, Precourt Institute for Energy

ADMINISTRATIVE APPOINTMENTS

- Director, High-Temperature Gasdynamics Laboratory, (1995- present)

HONORS AND AWARDS

- Tau Beta Pi Award For Excellence in Undergraduate Teaching, Stanford University (1994)

BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Vice President, Stanford Faculty Club (2012 - present)

PROFESSIONAL EDUCATION

- DSci, MIT (1975)
- ScD, MIT (1975)

PATENTS

- Turgut Gur, Reginald Mitchell, Andrew Lee, Siwen Li. "United States Patent 8,563,183 Integrated Dry Gasification Fuel Cell System for Conversion of Solid Carbonaceous Fuels", Leland Stanford Junior University, Oct 22, 2013

Teaching

STANFORD ADVISEES

Doctoral (Program)

Nguyen Ly

Publications

PUBLICATIONS

- **Numerical approaches for thermochemical conversion of char** *PROGRESS IN ENERGY AND COMBUSTION SCIENCE*
  Haugen, N. L., Loong, B., Mitchell, R. E.
  2022; 91
- **Insights into Sulfur Uptake by Solid Sorbents from Fossil Fuels and Biomass: Revisiting C-H-O Ternary Diagrams** *ENERGY & FUELS*
  Johnson, D. U., Mitchell, R. E., Gur, T. M.
  2018; 32 (12): 12066–80
- **High Heating Rate Devolatilization Kinetics of Pulverized Biomass Fuels** *ENERGY & FUELS*
  Johansen, J. M., Jensen, P. A., Glarborg, P., De Martini, N., Ek, P., Mitchell, R. E.
  2018; 32 (12): 12955–61
- **Comprehensive Char Particle Gasification Model Adequate for Entrained-Flow and Fluidized-Bed Gasifiers** *ENERGY & FUELS*
  Tilghman, M. B., Haugen, N. E., Mitchell, R. E.
  2017; 31 (3): 2164-2174
- **Impact of Co-firing Coal and Biomass on Mixed Char Reactivity under Gasification Conditions** *ENERGY & FUELS*
  Tilghman, M. B., Mitchell, R. E.
  2016; 30 (3): 1708-1719
- **Symptomatic Myocardial Bridging in D-Transposition of the Great Arteries Post-Arterial Switch** *JACC: Case Reports, Vol 8, Iss , Pp 101730- (2023)*
  Vaikunth, S. S., Murphy, D. J., Tremmel, J. A., Schnittger, I., Mitchell, R. S., Maeda, K., Rogers, I. S.
  2023
- **Extension of apparent devolatilization kinetics from thermally thin to thermally thick particles in zero dimensions for woody biomass** *ENERGY*
  Johansen, J. M., Jensen, P. A., Glarborg, P., Mancini, M., Weber, R., Mitchell, R. E.
  2016; 95: 279-290
- **Devolatilization kinetics of woody biomass at short residence times and high heating rates and peak temperatures** *APPLIED ENERGY*
  Johansen, J. M., Gadsboll, R., Thomsen, J., Jensen, P. A., Glarborg, P., Ek, P., De Martini, N., Mancini, M., Weber, R., Mitchell, R. E.
  2016; 162: 245-256
- **Modeling defect transport during Cu oxidation** *CORROSION SCIENCE*
  Goldstein, E. A., Guer, T. M., Mitchell, R. E.
  2015; 99: 53-65
- **Coal and biomass char reactivities in gasification and combustion environments** *COMBUSTION AND FLAME*
  Tilghman, M. B., Mitchell, R. E.

2015; 162 (9): 3220-3235

- **Modeling radiation in particle clouds: on the importance of inter-particle radiation for pulverized solid fuel combustion** *HEAT AND MASS TRANSFER*
  Haugen, N. E., Mitchell, R. E.
  2015; 51 (7): 991-999
- **A comprehensive model for char particle conversion in environments containing O-2 and CO2** *COMBUSTION AND FLAME*
  Haugen, N. E., Mitchell, R. E., Tilghman, M. B.
  2015; 162 (4): 1455-1463
- **An experimental study of the reactivity of cellulosic-based chars from wastes** *FUEL*
  Sorum, L., Campbell, P. A., Haugen, N. E., Mitchell, R. E.
  2014; 130: 306-314
- **The conversion mode of a porous carbon particle during oxidation and gasification** *COMBUSTION AND FLAME*
  Haugen, N. E., Tilghman, M. B., Mitchell, R. E.
  2014; 161 (2): 612-619
- **Modeling Power Production in a Tubular Carbon Fuel Cell** *IONIC AND MIXED CONDUCTING CERAMICS 9*
  Johnson, D. U., Mitchell, R. E., Guer, T. M.
  2014; 61 (1): 235-243
- **Modeling of experimental results for carbon utilization in a carbon fuel cell** *JOURNAL OF POWER SOURCES*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  2013; 228: 132-140
- **Characterizing char particle fragmentation during pulverized coal combustion** *PROCEEDINGS OF THE COMBUSTION INSTITUTE*
  Tilghman, M. B., Mitchell, R. E.
  2013; 34: 2461-2469
- **Modeling Heat Transfer Effects In a Solid Oxide Carbon Fuel Cell** *Symposium on Batteries and Energy Technol Joint Gen Sess in Honor of James McBreen held during the PRiME Joint Int Meeting of the Electrochem-Soc and the Electrochem-Soc-of-Japan*
  ARMSTRONG, G. J., Alexander, B. R., Mitchell, R. E., Guer, T. M.
  ELECTROCHEMICAL SOC INC.2013: 143–50
- **DEVELOPMENT OF A SYSTEM FOR THE STUDY OF SOLID FUEL CONVERSION UNDER SUPERCRITICAL WATER CONDITIONS** *ASME International Mechanical Engineering Congress and Exposition*
  Kim, B., Mitchell, R. E.
  AMER SOC MECHANICAL ENGINEERS.2013: 993–1003
- **Oxy-combustion of solid fuels in a carbon fuel cell** *PROCEEDINGS OF THE COMBUSTION INSTITUTE*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  2013; 34: 3445-3452
- **Experimental and Modeling Study of Biomass Conversion in a Solid Carbon Fuel Cell** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  2012; 159 (3): B347-B354
- **Coal and Biomass Utilization in Solid Oxide Fuel Cells** *International Symposia on Electrochemical Utilization of Solid Fuels*
  Mitchell, R. E.
  ELECTROCHEMICAL SOC INC.2012: 3–28
- **Model of Carbon Utilization in a Carbon Fuel Cell** *International Symposia on Electrochemical Utilization of Solid Fuels*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  ELECTROCHEMICAL SOC INC.2012: 45–55
- **Hydrogen and Electricity from Carbon in a Coupled Steam-Carbon-Air Fuel Cell** *International Symposia on Electrochemical Utilization of Solid Fuels*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  ELECTROCHEMICAL SOC INC.2012: 69–80

- **Viability of Coupled Steam-Carbon-Air Fuel Cell Concept for Spontaneous Co-Production of Hydrogen and Electrical Power** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  2012; 159 (12): F810-F818
- **Feasibility of hydrogen production in a steam-carbon electrochemical cell** *17th International Conference on Solid State Ionics*
  Lee, A. C., Mitchell, R. E., Guer, T. M.
  ELSEVIER SCIENCE BV.2011: 607–10
- **Steam-Carbon Fuel Cell Concept for Cogeneration of Hydrogen and Electrical Power** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  2011; 158 (5): B505-B513
- **Biomass Conversion in a Solid Oxide Fuel Cell** *12th International Symposium on Solid Oxide Fuel Cells (SOFC)*
  Alexander, B. R., Mitchell, R. E., Guer, T. M.
  ELECTROCHEMICAL SOC INC.2011: 2685–92
- **Chemical kinetics of copper oxide reduction with carbon monoxide** *PROCEEDINGS OF THE COMBUSTION INSTITUTE*
  Goldstein, E. A., Mitchell, R. E.
  2011; 33: 2803-2810
- **Carbon-Free Hydrogen Production in a Steam-Carbon Electrochemical Cell** *Symposium on Electrochemical Technologies for Hydrogen Production held during the 217th Meeting of the Electrochemical-Society*
  Alexander, B. R., Lee, A. C., Mitchell, R. E., Guer, T. M.
  ELECTROCHEMICAL SOC INC.2010: 67–76
- **Thermodynamic analysis of gasification-driven direct carbon fuel cells** *JOURNAL OF POWER SOURCES*
  Lee, A. C., Mitchell, R. E., Gur, T. M.
  2009; 194 (2): 774-785
- **Modeling of CO2 Gasification of Carbon for Integration with Solid Oxide Fuel Cells** *AICHE JOURNAL*
  Lee, A. C., Mitchell, R. E., Guer, T. M.
  2009; 55 (4): 983-992
- **Modeling char oxidation behavior under Zone II burning conditions at elevated pressures** *COMBUSTION AND FLAME*
  Ma, L., Mitchell, R.
  2009; 156 (1): 37-50
- **Direct carbon conversion in a helium fluidized bed fuel cell** *16th International Conference on Solid State Ionics*
  Li, S., Lee, A. C., Mitchell, R. E., Guer, T. M.
  ELSEVIER SCIENCE BV.2008: 1549–52
- **The impact of the distributions of surface oxides and their migration on characterization of the heterogeneous carbon-oxygen reaction** *COMBUSTION AND FLAME*
  Campbell, P. A., Mitchell, R. E.
  2008; 154 (1-2): 47-66
- **Conversion of solid carbonaceous fuels in a fluidized bed fuel cell** *ELECTROCHEMICAL AND SOLID STATE LETTERS*
  Lee, A. C., Li, S., Mitchell, R. E., Guer, T. M.
  2008; 11 (2): B20-B23
- **On the burning behavior of pulverized coal chars** *COMBUSTION AND FLAME*
  Mitchell, R. E., Ma, L., Kim, B.
  2007; 151 (3): 426-436
- **Characterization of coal char and biomass char reactivities to oxygen** *29th International Combustion Symposium*
  Campbell, P. A., Mitchell, R. E., Ma, L. Q.
  ELSEVIER SCIENCE INC.2002: 519–526
- **An intrinsic kinetics-based, particle-population balance model for char oxidation during pulverized coal combustion** *28th International Symposium on Combustion*

Mitchell, R. E.
ELSEVIER SCIENCE INC.2000: 2261–2270

- **Release of inorganic material during coal devolatilization** *COMBUSTION AND FLAME*
  Baxter, L. L., Mitchell, R. E., Fletcher, T. H.
  1997; 108 (4): 494-502

- **Nitrogen release during coal combustion** *ENERGY & FUELS*
  Baxter, L. L., Mitchell, R. E., Fletcher, T. H., Hurt, R. H.
  1996; 10 (1): 188-196

- **The impact of fragmentation on char conversion during pulverized coal combustion** *TWENTY-SIXTH SYMPOSIUM (INTERNATIONAL) ON COMBUSTION, VOLS 1 AND 2*
  Mitchell, R. E., Akanetuk, A. E.
  1996: 3137-3144

- **The temperature, burning rates and char character of pulverised coal particles prepared from maceral concentrates** *Twenty-Fourth Symposium on Combustion*
  Wall, T. F., Tate, A. G., Bailey, J. G., Jeness, L. G., Mitchell, R. E., Hurt, R. H.
  1992: 1207–1215

- **THE RELEASE OF IRON DURING THE COMBUSTION OF ILLINOIS NO-6 COAL** *COMBUSTION AND FLAME*
  Baxter, L. L., Mitchell, R. E.
  1992; 88 (1): 1-14

- **Unified high-temperature char combustion kinetics for a suite of coals of various rank** *Twenty-Fourth Symposium on Combustion*
  Hurt, R. H., Mitchell, R. E.
  1992: 1243–1250

- **On the combustion kinetics of heterogeneous char particle populations** *Twenty-Fourth Symposium on Combustion*
  Hurt, R. H., Mitchell, R. E.
  1992: 1233–1241

- **The release of iron during the combustion of Illinois No. 6 coal** *Combustion and Flame*
  Baxter, L. L., Mitchell, R. E.
  1992; 88 (1): 1-14

- **ON THE COMBUSTION KINETICS OF HETEROGENEOUS CHAR PARTICLE-POPULATIONS**
  Hurt, R. H., Mitchell, R. E.
  AMER CHEMICAL SOC.1991: 26-FUEL

- **The effect of CO conversion in the boundary layers surrounding pulverized-coal char particles** *Twenty-Third Symposium (International) on Combustion*
  Mitchell, R. E., Kee, R. J., Glarborg, P., Coltrin, M. E.
  1991: 1169–1176

- **Variations in the temperatures of coal-char particles during combustion: A consequence of particle-to-particle variations in ASH-content** *Twenty-Third Symposium (International) on Combustion*
  Mitchell, R. E.
  1991: 297–1304

- **NUMERICAL-SOLUTION OF CONFINED AXISYMMETRIC LAMINAR DIFFUSION FLAMES** *2ND WORKSHOP ON ADAPTIVE COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS*
  Smooke, M. D., Mitchell, R. E., Keyes, D. E.
  SIAM.1989: 125–150

- **THE INFLUENCE OF THE MINERAL MATTER CONTENT OF COAL ON THE TEMPERATURES AND BURNING RATES OF CHAR PARTICLES DURING PULVERIZED COAL COMBUSTION** *6TH ANNUAL INTERNATIONAL PITTSBURGH COAL CONF*
  Mitchell, R. E.
  UNIV PITTSBURGH SCHOOL ENGN.1989: 32–41

- **THE RELEASE OF IRON DURING THE COMBUSTION OF ILLINOIS =6 COAL** *6TH ANNUAL INTERNATIONAL PITTSBURGH COAL CONF*

Baxter, L. L., Mitchell, R. E.
UNIV PITTSBURGH SCHOOL ENGN.1989: 64–73

- **NUMERICAL-SOLUTION OF 2-DIMENSIONAL AXISYMMETRIC LAMINAR DIFFUSION FLAMES** *COMBUSTION SCIENCE AND TECHNOLOGY*
  Smooke, M. D., Mitchell, R. E., Keyes, D. E.
  1989; 67 (4-6): 85-122
- **RATES AND MECHANISMS OF COMBUSTION OF PULVERIZED COAL CHARS** *1989 REVIEW MEETING OF THE ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT DIRECT UTILIZATION, AND INSTRUMENTATION AND DIAGNOSTICS CONTRACTORS*
  Mitchell, R. E., HARDESTY, D. R.
  US DEPT ENERGY.1989: 33–42
- **EVIDENCE FOR FORMATION OF CO2 IN THE VICINITY OF BURNING PULVERIZED CARBON PARTICLES** *COMBUSTION AND FLAME*
  WATERS, B. J., Squires, R. G., Laurendeau, N. M., Mitchell, R. E.
  1988; 74 (1): 91-106
- **Experimentally determined overall burning rates of pulverized-coal chars in specified O2 and CO2 environments** *Twenty-First Symposuim (International on Combustion)*
  Mitchell, R. E.
  1988: 173–181
- **Solution of Two-Dimensional Axisymmetric Laminar Diffusion Flames by Adaptive Boundary Value Methods** *Mathematical Modeling in Combustion and Related Topics*
  Smooke, M. D., Turnbull, A. A., Mitchell, R. E., Keyes, D. E.
  1988: 261–300
- **EXPERIMENTALLY DETERMINED OVERALL BURNING RATES OF COAL CHARS** *COMBUSTION SCIENCE AND TECHNOLOGY*
  Mitchell, R. E.
  1987; 53 (2-3): 165-186
- **DETERMINATION OF OVERALL KINETIC RATES AND OXYGEN REACTION ORDER FOR SARAN CHAR COMBUSTION**
  Mitchell, R. E., WATERS, B. J., Squires, R. G., Laurendeau, N. M.
  AMER CHEMICAL SOC.1986: 2-FUEL
- **Simultaneous in situ measurement of the size, temperature and velocity of particles in a combustion environment** *Twentieth Symposium (International) on Combustion*
  Tichenor, D. A., Mitchell, R. E., Hencken, K. R., Niksa, S.
  1985: 1213–1221
- **OPTICALLY DETERMINED TEMPERATURES, SIZES, AND VELOCITIES OF INDIVIDUAL CARBON PARTICLES UNDER TYPICAL COMBUSTION CONDITIONS** *COMBUSTION AND FLAME*
  Niksa, S., Mitchell, R. E., Hencken, K. R., Tichenor, D. A.
  1985; 60 (2): 183-193
- **TEMPERATURE-MEASUREMENTS OF SINGLE PULVERIZED-FUEL PARTICLES BY 2-COLOR PYROMETRY**
  Mitchell, R. E., Niksa, S., McLean, W. J.
  ELECTROCHEMICAL SOC INC.1983: C106–C106
- **Toward a comprehensive chemical kinetic mechanism for the oxidation of acetylene: Comparison of model predictions with results from flame and shock tube experiments** *Nineteenth Symposium (International) on Combustion*
  Miller, J. A., Mitchell, R. E., Smooke, M. D., Kee, R. J.
  1982
- **On the temperature and reaction rate of burning pulverized fuels** *Nineteenth Symposium (International) on Combustion*
  Mitchell, R. E., McLean, W. J.
  1982: 1113–1122
- **NITRIC-OXIDE AND HYDROGEN-CYANIDE FORMATION IN LAMINAR METHANE-AIR DIFFUSION FLAMES** *COMBUSTION SCIENCE AND TECHNOLOGY*
  Mitchell, R. E., SAROFIM, A. F., Yu, R.
  1980; 21 (3-4): 157-167

- **PARTIAL EQUILIBRIUM IN THE REACTION ZONE OF METHANE-AIR DIFFUSION FLAMES** *COMBUSTION AND FLAME*
  Mitchell, R. E., SAROFIM, A. F., CLOMBURG, L. A.
  1980; 37 (2): 201-206
- **EXPERIMENTAL AND NUMERICAL INVESTIGATION OF CONFINED LAMINAR DIFFUSION FLAMES** *COMBUSTION AND FLAME*
  Mitchell, R. E., SAROFIM, A. F., CLOMBURG, L. A.
  1980; 37 (3): 227-244
- **COMPARISON OF RAMAN AND THERMOCOUPLE TEMPERATURE-MEASUREMENTS IN FLAMES** *COMBUSTION AND FLAME*
  SCHOENUNG, S. M., Mitchell, R. E.
  1979; 35 (2): 207-211
- **Overall kinetic parameters for combustion of a highly non-spherical carbon char** *Twenty-Second Symposium (International) on Combustion*
  Walters, B. J., Mitchell, R. E., Squires, R. G., Laurendeau, N. M.
  : 17–27
- **On the products of the heterogeneous oxidation reaction at the surfaces of burning coal char particles** *Twenty-Second Symposium (International) on Combustion*
  Mitchell, R. E.
  : 69–78
- **NUMERICAL SOLUTION OF A CONFINED LAMINAR DIFFUSION FLAME** *Elliptic Problem Solvers Conference*
  Smooke, M. D., Mitchell, R. E., Grcar, J. F.
  1984: 557–568