

# SATBIR SINGH

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## RESEARCH INTERESTS

Development of large-eddy simulation (LES) models for turbulent flows  
Modeling of combustion using level-set methods and detailed chemistry  
Numerical investigation of effect of turbulent mixing on combustion aerosol nucleation and growth  
Combustion of alternative fuels (hydrogen, bio-fuels, natural gas etc.)  
Application of high fidelity CFD models to practical devices

## EDUCATION

- PhD in Mechanical Engineering** Aug. 2006  
University of Wisconsin - Madison.  
Advisor: Rolf. D. Reitz  
Dissertation Title: Experimental investigation of multi-mode diesel engine combustion to validate advanced computational models.
- MS in Mechanical Engineering** Aug. 2002  
University of Alabama - Tuscaloosa.  
Advisor: K. Clark Midkiff  
Thesis Title: The effect of fuel injection timing and diesel pilot quantity on pollutant emissions from a pilot ignited, natural gas, dual-fuel engine.
- BS in Mechanical Engineering** May 2000  
Guru Nanak Dev Engineering College, Ludhiana, India.  
Undergraduate Project: Design and fabrication of engine exhaust muffler for noise reduction.

## RESEARCH EXPERIENCE

- Research Staff, Carnegie Mellon University - Pittsburgh** (February, 2010 – Present)
- Development and assessment of grid-independent large eddy simulation (LES) models using explicit filters. A new dynamic global coefficient mixed model is formulated and validated for a number of flow configurations.
  - Development of finite-volume structured code for simulation of flows in complex geometries. The newly proposed numerical scheme requires less computational time and memory compared to unstructured methods.
  - Numerical investigation of effect of turbulent mixing on aerosol formation and growth via Eulerian coupling of aerosol population balance equation (PBE) with equations of motion for turbulent flows.
- Senior Researcher, General Motors Research and Development, Warren, MI** (October, 2006 – January, 2010)
- Assessment of advanced combustion and emissions models for spark-ignited and compression-ignited engines.
  - Investigation of competing rates of flame propagation and auto-ignition in an HCCI engine using chemistry-based combustion models.
  - Evaluation of advanced injection technologies for reduced pollutant emissions and improved fuel economy in diesel engine combustion systems.
- Graduate Research Assistant, University of Wisconsin - Madison** (September, 2002 – August, 2006)
- Validation of detailed-chemistry, flamelet (RIF), and time-scale based ignition and combustion models implemented in KIVA code using detailed in-cylinder measurements obtained from an optical, heavy-duty, direct-injection diesel engine.
  - Development of a level-set-based (G-equation), hybrid auto-ignition and flame-propagation model for combustion. The newly proposed G-equation-CHEMKIN based model provides a common platform to simulate both flame propagation and auto-ignition in turbulent reacting flows.
- Visiting Researcher, Sandia National Laboratories, Livermore, CA** (August, 2004 – March, 2005)
- Investigation of multi-mode (high- and low-temperature) combustion in an optically accessible, heavy-duty, DI diesel engine using 2-color thermometry experiments and in-cylinder laser diagnostics including OH-PLIF, soot-LII, ignition chemiluminescence, and Mie scattering from liquid fuel droplets.

### **Graduate Research Assistant**

**University of Alabama - Tuscaloosa** (June, 2001 – August, 2002)

- Experimental investigation of pollutant emissions and performance of a diesel/natural-gas dual-fuel engine operating with very low diesel-pilot quantities.

### **Graduate Lab Assistant**

**University of Alabama - Tuscaloosa** (Jan, 2001 – May, 2001)

- Designed and fabricated experimental apparatus for fluid mechanics laboratory for measuring pressure loss in hydraulic valves and fittings.

## **TEACHING EXPERIENCE**

### **Internal Combustion Engines (ME 421)**

Carnegie Mellon University - Pittsburgh (Fall 2010, Fall 2011)

### **Applied Combustion (ME 744)**

Carnegie Mellon University - Pittsburgh (Spring 2012)

### **SAE Faculty Co-Advisor**

Carnegie Mellon University - Pittsburgh (2011-2012)

## **PROFESSIONAL ACTIVITIES**

### **Technical Meeting Organizer**

- SAE Fuels and Lubricants meeting, Florence, Italy, June 2009. Session organizer for Multi-Dimensional Modeling section.
- Combustion Institute joint meeting, Ann Arbor, MI, May 2009.
- SAE Fuels and Lubricants meeting, IL, October 2008. Session organizer for Alternative Fuels section.

### **Grant Reviewer**

- National Science Foundation (NSF)

### **Technical Paper Reviewer**

- Journal of Computational Physics
- Computers and Fluids
- Physics of Fluids
- Fuels
- Energy
- Combustion Science and Technology
- Combustion and Flame
- International Journal of Engine Research (IJER)
- Society of Automotive Engineers (SAE)
- American Society of Mechanical Engineers (ASME)

## **PUBLICATIONS**

### **Journal Publications**

**S. Singh** and D. You (2012). A Dynamic Global-Coefficient Mixed Subgrid-Scale Model for Large-Eddy Simulation of Turbulent Flows. *Physics of Fluids*, submitted.

**S. Singh**, S. T. Bose, and D. You (2012). Large-Eddy Simulation of Turbulent Channel Flow using Explicit Filtering and Dynamic Mixed Models. *Journal of Computational Physics*, submitted.

**S. Singh** and D. You (2011). A Multi-Block ADI Finite-Volume Method for Incompressible Navier-Stokes Equations in Complex Geometries. *Journal of Computational Physics*, Vol. 230, No. 19, pp. 7400-7417.

**S. Singh** and M. P. B. Musculus (2010). Numerical Modeling and Analysis of Entrainment in Turbulent Jets after the End of Injection. *ASME Journal of Fluids Engineering*, 132, 081203.

- S. Singh**, M. P. B. Musculus, and R. D. Reitz (2009). Mixing and Flame Structures Inferred from OH-PLIF for Conventional and Low-Temperature Diesel Engine Combustion. *Combustion and Flame*, Vol. 156, pp. 1998-1908.
- R. Diwakar and **S. Singh** (2008). NO<sub>x</sub> and Soot Reduction in Diesel Engine PCCI Combustion: A Computational Investigation. *International Journal of Engine Research*. Vol. 9, No. 3, pp. 195-214.
- M. P. B. Musculus, **S. Singh**, and R. D. Reitz (2008). Gradient Effects on Two-Color Soot Optical Pyrometry in a Heavy-Duty DI Diesel Engine. *Combustion and Flame*, 153, pp. 216-227.
- T. Lachaux, M. P. B. Musculus, **S. Singh**, and R. D. Reitz (2008). Optical Diagnostics of Late Injection Low-Temperature Combustion in a Heavy Duty Diesel Engine. *Trans. ASME, J. Eng. Gas Turbines Power*, Vol. 130, No. 3, pp. 1-9.
- S. Singh**, R. D. Reitz, M. P. B. Musculus, and T. Lachaux (2007). Investigation of Low-Temperature, Double-Injection Combustion using Simultaneous Optical Diagnostics in a Heavy-Duty DI Diesel Engine. *Combustion Science and Technology*, Vol. 179, No. 11, pp. 2381-2414.
- S. Singh**, R. D. Reitz, M. P. B. Musculus, and T. Lachaux (2007). Validation of Engine Combustion Models against Detailed In-Cylinder Optical Diagnostics for a Heavy-Duty Compression-Ignition Engine. *International Journal of Engine Research*, Vol. 8, No. 1, pp. 97-126.
- K. K. Srinivasan, S. Krishnan, **S. Singh**, K. C. Midkiff, S. R. Bell, W. Gong, S. Fiveland, and M. Willi (2006). The Advanced Injection Low Pilot Ignited Natural Gas Engine - A Combustion Analysis. *Trans. ASME, J. Eng. Gas Turbines Power*, Vol. 128, No. 1, pp. 213-218.
- S. Singh**, L. Liang, S-C Kong, and R. D. Reitz (2006). Development of a Flame Propagation Model for Dual-Fuel Partially Premixed Compression Ignition Engines. *Journal of Engine Research*, Vol. 7, No. 1, pp. 65-76.
- S. Singh**, S. R. Krishnan, K. K. Srinivasan, K. C. Midkiff, and S. Bell (2004). Effect of Pilot Injection Timing, Pilot Quantity, and Intake Charge Conditions on Performance and NO<sub>x</sub> Emissions for an Advanced Low-Pilot-Ignited Natural Gas Engine. *International Journal of Engine Research*, Vol. 5, No. 4, pp. 329-348.
- S. R. Krishnan, K. K. Srinivasan, **S. Singh**, S. Bell, K. C. Midkiff, W. Gong, S. Fiveland, and M. Willi (2004). Strategies for Reduced NO<sub>x</sub> Emissions in a Pilot Ignited Natural Gas Engine. *Trans. ASME, J. Eng. Gas Turbines Power*, Vol. 126, No. 3, pp. 665-671.
- S. Singh** and M. A. R. Sharif (2003). Mixed Convective Cooling of a Rectangular Cavity with Inlet and Exit Openings on Differentially Heated Side Walls. *Numerical Heat Transfer, Part A*, Vol. 44, No. 3, pp. 233-253.

### **SAE Journal Transactions**

- S. Singh**, R. D. Reitz, D. Wickman, D. W. Stanton, and Z. Tan (2007). Development of a Hybrid, Auto-Ignition/Flame-Propagation Model and Validation against Engine Experiments and Flame Liftoff. SAE 2007-01-0171. *SAE Transactions Journal of Passenger Cars: Mechanical Systems*, 116(6).
- S. Singh**, R. D. Reitz, and M. P. B. Musculus (2006). Comparison of the Characteristic Time (CTC), Representative Interactive Flamelet (RIF), and Direct Integration with Detailed Chemistry Combustion Models against Optical Diagnostics Data for Multi-Mode Combustion in a Heavy-Duty DI Diesel Engine. SAE 2006-01-0055. *SAE Transactions Journal of Engines*, 115(3), pp. 61-82.
- S. Singh**, R. D. Reitz, and M. P. B. Musculus (2005). Thermometry Experiments and High Speed Imaging of Multi-Mode Diesel Engine Combustion. SAE 2005-01-3842, *SAE Transactions Journal of Fuels and Lubricants*, 114(4), pp. 1605-1621.
- S. Singh**, S-C Kong, R. D. Reitz, S. R. Krishnan, and K. C. Midkiff (2004). Modeling and Experiments of Dual-Fuel Engine Combustion and Emissions. SAE 2004-01-0092, *SAE Transactions Journal of Fuels and Lubricants*, 113(4), pp. 124-133.

### **Peer-Reviewed Conference Papers**

- S. Singh**, S. Liu, and H. Li (2012). Numerical Investigation of NO<sub>2</sub> Formation Mechanism in H<sub>2</sub>-Diesel Dual-Fuel Engine. SAE 2012-01-0655.

**S. Singh**, S. T. Bose, and D. You (2011). Accuracy of Subfilter-Scale Models for Explicit Filter Large-Eddy Simulation in Turbulent Channel Flow. Turbulence and Shear Flow Phenomena (TSFP-7), July 28-31, Ottawa, Canada.

P. Boggavarpu and **S. Singh** (2011). Computational Study of Injection Rate-Shaping for Emissions Control in Diesel Engines. SAE 2011-26-0081.

R. Diwakar and **S. Singh** (2009). Importance of Spray-Bowl Interaction in a DI Diesel Engine Operating Under PCCI Combustion Mode. SAE 2009-01-0711.

B. Hu, R. Jhavar, **S. Singh**, R. D. Reitz, and C. Rutland (2007). LES Combustion Modeling of Diesel Combustion with Partially Premixed Conditions. SAE 2007-01-0163.

### **Non Peer-Reviewed Conference Presentations**

**S. Singh** and D. You (2011). A Dynamic Global-Coefficient Mixed Subgrid-Scale Model for Large-Eddy Simulation of Turbulent Flows. 64<sup>th</sup> Annual Meeting of the APS Division of Fluid Dynamics, Nov. 20-22, MD.

A. Sifounakis, D. You and **S. Singh** (2011). A Fully-Conservative Finite-Volume Method for Incompressible Navier-Stokes Equations on Locally-Refined Nested Cartesian Grids. 64<sup>th</sup> Annual Meeting of the APS Division of Fluid Dynamics, Nov. 20-22, MD.

**S. Singh** and D. You (2010). A Finite Volume ADI Method for Simulation of Incompressible Flows on Curvilinear Grids. Presented at 63<sup>rd</sup> Annual Meeting of the APS Division of Fluid Dynamics, Nov. 21-23, CA.

**S. Singh** and M. P. B. Musculus (2009). Numerical Modeling Study of Entrainment and Mixing in a Decelerating Transient Gas-Jet. Presented at 6<sup>th</sup> U.S. National Meeting of the Combustion Institute, May 17-20, Ann Arbor, MI.

H. W. Won, A. Sharma, P. Hottenbach, M. Gauding, F. X. Robert, N. Peters, G. Gruenefeld, R. Durrett, A. Plazas, **S. Singh** (2009). Investigation of Particulate Emissions from Cluster-Nozzle Concepts in DI Diesel Engines. ICLASS2009.

**S. Singh**, M. P. B. Musculus, and R. D. Reitz (2008). Diesel Engine Autoignition and Flame Structure in High- and Low-Temperature Combustion Modes. Presented at 2008 Spring Technical of the Central States Section of the Combustion Institute, April 20-22, Tuscaloosa, AL.

**S. Singh** and M. A. R. Sharif (2002). Numerical Study of Mixed-Convective Cooling of a Rectangular Cavity with Differentially Heated Side Walls. Energy Conversion Engineering Conference, IECEC 2002, Paper No. 20108.