

# Varun Goyal

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EDUCATION	<p><b>University of Michigan</b>, Ann Arbor, MI, USA August 2020 - Present</p> <p>Doctor of Philosophy (Ph.D.) in Mechanical Engineering (GPA 4/4) Advisor: Prof. Karl Grosh</p> <p><b>Indian Institute of Technology Madras</b>, Chennai, TN, India August 2015 - July 2020</p> <p>B-Tech. + M-Tech. (Dual Degree) in Mechanical Engineering with specialization in Mechanical Design (GPA 9.09/10)</p> <p><b>Nanyang Technological University</b>, Singapore August 2018 - December 2018</p> <p>Exchange semester in Mechanical Engineering</p>
RESEARCH EXPERIENCE	<p><b>Graduate Student Research Assistant</b> August 2020 - Present</p> <p><b>Nonlinear Model of a Mammalian Cochlear Outer Hair Cell (OHC) Hair Bundle (HB)</b> <i>Supervised by Prof. Karl Grosh, Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI, USA</i></p> <ul style="list-style-type: none"><li>• Developing a multi-specie, nonlinear dynamic model for the motion of stereocilia protruding from mechano-receptors (OHCs) by regarding cells, ion channels, and proteins as mechanical systems</li><li>• The project aims at understanding the consistent natural occurrence of three rows of stereocilia in a HB of most mammalian cochlea by developing and comparing three-row and two-row models</li><li>• Hypothesizing mechanisms for adaptation of the mechano-electric transducer (MET) current by modeling the action of myosin-actin interaction that may be affected by intracellular ion concentration</li><li>• Studying the key difference between a two-row and a three-row model, i.e., prediction of an additional adaptation time constant by the latter, that may provide better experimental fits, estimate biophysical parameters, and potentially bring us closer to evaluating the role of the third row of stereocilia</li></ul> <p><b>Modeling the Effects of Fluid Shear Excitation vs. Direct Mechanical Stimulation of the Inner Hair Cell (IHC) Hair Bundle (HB)</b> <i>Supervised by Prof. Karl Grosh, Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI, USA</i></p> <ul style="list-style-type: none"><li>• Experimental investigations using imaging are inconclusive of whether the IHC HB tallest stereociliary rows are embedded into the TM or is putatively free-floating in the surrounding fluid</li><li>• Developing an analytical model for IHC HB situated inside the fluid-filled region between Reticular Lamina (RL) and Tectorial Membrane (TM) using viscous Navier-Stokes and continuity equations</li><li>• The project aims at studying the implications of viscous fluid forcing vs. direct mechanical stimulation of HB (via TM) coupled with nonlinear dynamics developed in the first project on receptor potential and MET current responses in both time and frequency domains</li></ul>
PUBLICATIONS	<p>[1] <b>Goyal, Varun</b>, and Grosh, Karl. Modeling the nonlinear mechanics and dynamics of Cochlear Outer Hair Cell Stereocilia. <i>The Journal of the Acoustical Society of America</i>, 153, no. 3_supplement (2023): A162-A162. DOI: <a href="https://doi.org/10.1121/10.0018516">10.1121/10.0018516</a></p> <p>[2] <b>Goyal, Varun</b>, and Grosh, Karl. Hair Bundle Micromechanics Including Stereocilia Kinematics and the Interaction of Stimulus and Bundle Rate Constants. <i>AIP Conference Proceedings</i>, (2022) (Accepted)</p> <p>[3] <b>Goyal et al.</b> CFD and Experimental Analysis of Swirl Type Single-Fluid Atomizer for Optimization of Recrystallization Process to Make Ultrafine RDX Explosive. <i>Propellants, Explosives, Pyrotech-</i></p>

CONFERENCE PRESENTATIONS	<b>Acoustical Society of America, Chicago, Illinois, <i>Poster Presentation</i></b> Modeling the Nonlinear Mechanics and Dynamics of Cochlear Outer Hair Cell Stereocilia	May 2023
	<b>Association for Research in Otolaryngology, Orlando, Florida, <i>Podium Presentation</i></b> The Nonlinear Mechanics and Dynamics of a Three-Row Hair Bundle Model	February 2023
	<b>Mechanics of Hearing (MoH), Helsingör, Denmark, <i>Poster Presentation</i></b> Hair Bundle Micromechanics Including Stereocilia Kinematics and the Interaction of Stimulus and Bundle Rate Constants	July 2022
	<b>Midwest Auditory Research Conference, Ann Arbor, Michigan, <i>Poster Presentation</i></b> Interaction between Stimulus and Hair Bundle Rate Constants and a Kinetic Model of Stereocilia with Higher Fidelity Kinematic Relations	June 2022
	<b>Association for Research in Otolaryngology, <i>Poster Presentation</i></b> Modeling the Interaction of Stimuli and Adaptive Rate Constants on OHC HB Response	February 2022
INVITED SEMINARS	<b>Nonlinear Model for the Mechanics and Dynamics of Cochlear Outer Hair Cell Stereocilia</b> Graduate Seminar, Michigan Centre for Applied and Interdisciplinary Mathematics (MCAIM) University of Michigan, Ann Arbor, MI, USA, 7 April 2023	2023
PEER REVIEWER	Journal of Intelligent Material Systems and Structures	December 2022
	Journal of Intelligent Material Systems and Structures	March 2022
AWARDS & HONORS	<b>Association for Research in Otolaryngology (ARO) Conference Travel Grant</b>	February 2023
	<b>Mechanics of Hearing (MoH) Conference Travel Grant</b> From Loma Linda Veterans Association for Research and Education	July 2022
	<b>Rackham Travel Grant</b> From William & Flora Hewlett Foundation for MoH, 2022	July 2022
	<b>Alumni Funded Travel Grant</b> From IIT Madras for research internship at RWTH Aachen University, Germany	May 2019
	<b>Temasek Foundation International LEARN Scholarship</b> Awarded to only 40 students in Asia	July 2018
	<b>First in Project X</b> Support stand built from newspaper withstanding a weight of 30 Kgs	October 2015
	<b>Laureate Certificate in Mathematics</b>	July 2015
	<b>Bronze Medal in National-Level Table Tennis Competition</b>	2013
TEACHING EXPERIENCE	<b>Graduate Student Instructor</b> ME 240 Introduction to Dynamics and Vibrations	Fall 2023
	<b>Graduate Student Instructor</b> ME 240 Introduction to Dynamics and Vibrations	Winter 2023

## **Masters' Candidate**

January 2019 - July 2020

### **Structural Health Monitoring and Temperature Measurement of Composites using Guided Ultrasonic Waves**

*Supervised by Prof. Krishnan Balasubramaniam, Department of Mechanical Engineering, Indian Institute of Technology Madras, Chennai, TN, India*

- Numerically and analytically developed a dual function acoustic waveguide for efficient transmission of acoustic energy and using the guided ultrasonic wave to measure substrate temperature distribution
- Designed an acoustic fibre by numerically modeling specific materials clad around a cylindrical waveguide based on Snell's law and total internal reflection (TIR) to imitate an optical fibre
- Achieved low acoustic energy attenuation; for the temperature measurement, the claddings were removed from small segments at equal intervals enabling localized wave leaking
- Attained the temperature distribution of a substrate using the developed acoustic fibre through the pulse-echo method with reflected waves primarily originating from the non-cladded segments

### **Speciation Study of Counter-Flow Flames under Oxy-Fuel Conditions**

May 2019 - July 2019

*Supervised by Prof. Heinz Pitsch, Institut für Technische Verbrennung, RWTH Aachen University, Aachen, Germany*

- Investigated the combustion chemistry of non-premixed counter-flow flames of 1-butene (alone and mixed with  $CH_4$ ,  $C_2H_2$ , and  $C_3H_6$ ) under oxy-fuel conditions using a *Molecular Beam Mass Spectrometer* equipped with *Time-of-Flight* detection
- Reduced the complexity of kinetics by simulating the flame in 1-D on *FLAMEMASTER*
- Achieved strong signal detection from various organic compounds by calibrating them based on their natural occurrences and categorizing into liquids ( $C_6H_6$ ), gases ( $C_2H_2$ ), intermediates ( $C_3H_3$ ), and isomers ( $C_5H_8$  and  $C_3H_4$ )

### **Modeling the Cold Spray Bond to Predict its Mechanical Properties**

January 2019 - July 2019

*Supervised by Prof. M. Kamaraj, Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai, TN, India*

- Developed 2-D models for metallic powders of copper, titanium, and stainless steel cold sprayed on aluminum substrates
- Designed an ALE mesh model to compute the porosity, flattening ratios, bonding factors, and adhesion in thermal boost-up zone as plastic dissipation and recoverable strain energy
- Discerned particle jetting near the edges owing to adiabatic shear instability
- Successfully corroborated the numerical findings with experiments performed at Plasma Giken Co. Ltd., Kumagaya, Saitama Prefecture, Japan

### **Evaluating the Mechanical Properties of Trip Steel Joined by Friction Stir Welding**

May 2018

*Supervised by Prof. M. Okazaki, Department of Material Science and Engineering, Nagaoka University of Technology, Nagaoka, Niigata, Japan*

- Analyzed crystallographic variations and hardness in HAZ, TMAZ, and Stir Zone (SZ)
- Reported both small and large misorientations in HAZ and TMAZ, and a non-uniform distribution of smaller, equiaxed grains due to complete recrystallization in the SZ

### **Design of Atomizers for Generation of Ultra-Fine Particles**

December 2017 - January 2018

*Supervised by Dr. Dinesh Pal (Scientist 'F') and Dr. Shallu Gupta (Scientist 'E'), Terminal Ballistics Research Laboratory (TBRL), Defense Research and Development Organisation (DRDO), India*

- Designed pre-filming twin-fluid and single-fluid atomizers both theoretically and numerically to produce ultra-fine sub-micron level energetic particles and experimentally verified the results
- Developed atomizers with swirl channels of 400  $\mu m$  dimension to generate a high angular momentum
- Built a credible DPM, multiphase,  $k - \epsilon$  turbulent, RNG numerical model predicting particle size of 50 nm and 3  $\mu m$  for twin-fluid and single-fluid atomizers, respectively

INDUSTRIAL EXPERIENCE	<b>Summer Intern</b>	June 2018 - July 2018
	<i>Plasma Giken Co., Ltd., Kumagaya, Saitama Prefecture, Japan</i> <ul style="list-style-type: none"> <li>Analysed the mechanical and bonding properties at various pressure and temperature conditions of cold sprayed Copper, Titanium &amp; Stainless Steel on Aluminum substrates</li> <li>Etched samples and performed experiments using PCS-100 Cold Spray gun, Yaskawa Robot Arm, Tensile Testing Machine, SEM, and Vickers Hardness Measuring Instrument</li> <li>Observed hardness and strength to be more than base metals with high deposition efficiency</li> </ul>	
	<b>Project Intern</b>	September 2017 - November 2017
	<i>Mondelez International, Andhra Pradesh, India</i> <ul style="list-style-type: none"> <li>A global project aimed at minimizing the manufacturing plant's carbon dioxide emissions by 33% through optimization of the input parameters in HVAC, Boiler and Solar Panels</li> <li>Optimized HVACs and developed a standalone playbook (GUI) that estimated the net cost of production, CO2 emissions, savings, and suggested alternative fuels with lesser emissions</li> <li>Aided plants worldwide by reducing 50 kt of CO2 emissions, &amp; saving \$10 million yearly</li> </ul>	
SERVICES	<b>Graduate Vice President</b>	Fall 2022
	Tau Beta Pi, Michigan Gamma, University of Michigan, Ann Arbor, MI, USA	
	<b>International Volunteer</b>	August 2018 - December 2018
	Institute of Mental Health, Singapore	
	<b>Engineers Without Borders</b>	2016
	IIT Madras Chapter: Helped raise funds and highlight NGO's work	
	<b>Non-Government Organization, Alexis</b>	2010
	Patiala Chapter: Helped raise INR 50,000 for differently-abled children	