IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Computational Modeling of Atomization and Breakup of Superheated Sprays**	
Project Number	**IMURA1142**	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	***Artificial Intelligence and Advanced Computational Modelling***
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Circular Economy*
3	***Math, CFD, Modelling, Manufacturing***	3	***Clean Energy***
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Health Sciences*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Smart Materials*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Sustainable Societies*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Infrastructure*
8	*HSS, Design, Management*		

The research problem

The atomization and breakup of superheated sprays is a critical process with extensive applications in various industries, such as automotive, aerospace, and power generation. Atomization is a fundamental process in spray formation, wherein a liquid is broken into droplets through various mechanisms like primary and secondary breakup. When dealing with superheated sprays, the additional thermal energy introduced complicates the atomization process. Thus, a comprehensive computational model is essential to study this complex phenomenon and optimize spray applications.

The proposed research aims to utilize computational fluid dynamics (CFD) and multiphase flow modeling techniques to gain insights into the atomization and breakup mechanisms, which will ultimately lead to improved efficiency and performance in practical engineering applications.

Project aims

The primary objectives of this research proposal are as follows:

a. Develop a high-fidelity computational model to simulate the atomization of superheated sprays.

b. Investigate the influence of various parameters, such as liquid properties, nozzle geometry, and ambient conditions, on spray atomization.

c. Validate the computational model against experimental data to ensure accuracy and reliability.

d. Optimize spray parameters to improve the efficiency and performance of practical engineering applications.

How skills/experience of the IITB and the Monash supervisor(s) support the proposed project

Monash Supervisor : Has experience in both experimental measurements and numerical simulation of sprays, with a particular focus on internal nozzle flows and X-ray measurement techniques. The Monash Supervisor will provide access for the IITB student to the laboratory facilities at Monash and share data relevant to the project. The Monash Supervisor will also support applications for access to high performance computing resources (i.e. NCMAS grant applications).

IIT Bombay Supervisor: Has experience in developing computational models and numerical methods. The development of atomisation and breakup models for spray systems has been one of the research areas with an established track record.

What is expected of the student when at IITB and when at Monash?

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Methodology:

The proposed research will utilize advanced computational techniques, including CFD and multiphase flow modeling, to simulate the atomization process of superheated sprays. The modeling approach will include the following steps:

a. Governing Equations: The Navier-Stokes equations, augmented with additional terms for heat and mass transfer, will be solved to describe the fluid flow, heat transfer, and vaporization in the superheated spray.

b. Turbulence Modeling: To account for the turbulent nature of the atomization process, a suitable turbulence model, such as the Reynolds-Averaged Navier-Stokes (RANS) equations, will be employed.

c. Droplet Breakup Model: The primary and secondary breakup mechanisms will be incorporated into the model to predict droplet size distributions accurately.

d. Phase Change and Vaporization: The enthalpy-porosity method will be used to handle the phase change and vaporization of the superheated liquid.

Validation and Verification:

To ensure the accuracy and reliability of the computational model, it will be validated against experimental data from existing studies on superheated spray atomization. These include high-speed imaging and droplet size measurements conducted in the Monash supervisor's laboratory at the Clayton campus. The comparison between the computational and experimental results will be used to fine-tune the model parameters and optimize its performance.

The student is largely expected to develop the model at IIT Bombay in conjunction with support from advisor at Monash. Experiments and validation studies are proposed to be done at the facility in Monash.

Expected outcomes

The proposed research will contribute significantly to the understanding of the atomization process in superheated sprays, leading to several benefits:

a. Improved Efficiency: The computational model will allow optimization of spray parameters, leading to improved combustion efficiency and reduced emissions in combustion-based systems.

b. Design Optimization: The insights gained from the simulations can be used to design better fuel injectors and spray nozzles tailored for superheated spray applications.

c. Cost-Effectiveness: By reducing the reliance on expensive and time-consuming experimental studies, the proposed computational model offers a cost-effective approach for studying atomization in superheated sprays.

How will the project address the Goals of the above Themes?

The project aims to gain better physical understanding of the atomization and breakup processes of superheated flows. This has significant impact on improving the efficiencies of power generation in traditional steam power plants, aerocombustors and large internal combustion engines. This is tied with clean energy and advanced computational modeling themes.

How well the IITB and the Monash supervisor(s) know each other

The proposed supervisors met in person during the previous IIT Bombay delegation visit to Monash University and have discussed possible areas of research collaboration.

Potential RPCs from IITB and Monash

1. Sreedhara Seshadri (experience in computational modeling of combustion)
2. Upendra Bhandarkar (experience in development of numerical methods)
3. Bhalchandra Puranik (experience in CFD and compressible flows)

Capabilities and Degrees Required

Requirements
Master's degree preferred in Mechanical , Aerospace, Chemical or related engineering field. Strong background in applied mathematics and excellent programming skills.

Necessary Courses

1. Fluid Mechanics (Post graduate)
2. Thermodynamics (Post graduate)
3. Heat Transfer (Post graduate)
4. Advanced Engineering Mathematics.

Potential Collaborators

K**eywords** relating to this project to make it easier for the students to apply.

CFD, Fluid Mechanics, Numerical Modeling