Ph.D. Thesis Offer

Title: Theoretical and Numerical Investigation of Vortex Generator (VG) Dynamics and Heat Transfer Enhancement in Turbulent Chaotic Flow Regimes

Keyword: Mass Transfer Enhancement ; Mixing Fluid Flows; Vortex Generator Dynamics ; Numerical Simulation

Introduction

This Ph.D. program presents a comprehensive exploration of vortex generator (VG) dynamics and its impact on enhancing heat transfer in turbulent chaotic flow regimes, particularly near bifurcation regions. Through theoretical and numerical investigations, the study aims to unravel the fundamental mechanisms governing these phenomena, with the ultimate goal of advancing our understanding and devising innovative methodologies for enhancing heat transfer in diverse engineering applications, such as renewable energy and energy consumption. Past research has extensively explored computational modeling of vortical structures. Examples include investigating laminar vortex ring evolution and wake structures of micro-ramp vortex generators in bounded flows. Various longitudinal RVG designs have been studied to enhance heat transfer and reduce pumping energy.

Research Objectives

1. Develop advanced theoretical frameworks to analyze VG-induced flow dynamics and heat transfer enhancement in turbulent chaotic flow.
2. Employ state-of-the-art numerical simulation techniques, including computational fluid dynamics (CFD), to delve into the intricate interactions between VGs, turbulence, and heat transfer.
3. Explore novel design concepts and optimization strategies for VG configurations to maximize heat transfer enhancement while minimizing energy consumption and adverse effects.
4. Validate theoretical models and numerical simulations through rigorous numerical test cases.
5. Extend the applicability of VG-based heat transfer enhancement methods to renewable energy systems and cooling systems for heat evacuation or extraction.

Program Structure

Year 1:

- Coursework: Foundational courses in fluid mechanics, heat transfer, numerical methods, and turbulence modeling.
- Literature Review: Conduct an extensive review of relevant literature on vortex generators, turbulent flow, and heat transfer enhancement techniques.
- Preliminary Research: Initiate investigations into theoretical models and numerical simulations of VG-induced flow dynamics.

Year 2:

- Advanced Numerical Simulations: Refine numerical models and conduct detailed simulations to explore VG effects on heat transfer enhancement under varying flow conditions.
- Assessment and validation: examination of numerical prediction and VG efficiency in comparison with existing open-science laboratory-scale turbulent flow data.
- Publication: Prepare and submit research findings to peer-reviewed journals and conferences.

Year 3:

- Optimization and Design: Utilize insights from theoretical analyses, numerical simulations, and existing literature data to optimize VG configurations for specific heat transfer applications.
- Publications and Participation in Scientific Conferences: Present research findings in scientific conferences and publish in peer-reviewed journals.
- Thesis Writing: Compile research results into a comprehensive thesis document and defend the dissertation.

Outcome: Graduates of this Ph.D. program will acquire a profound understanding of vortex generator dynamics, turbulent flow phenomena, and heat transfer enhancement mechanisms. They will be well-prepared to pursue careers in academia, research institutions, or industry, where they can contribute to the development of efficient and sustainable engineering solutions.

Requirement for the position: Master degree in fluid mechanics and heat transfer.

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