INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: A numerical investigation on augmented heat flux in non-standard variants of turbulent Rayleigh-Bénard convection

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Thesis Submitted to the Department/ Center	:	Mechanical Engineering
Date of completion of Thesis Viva-Voce Exam	:	27/06/2023
Key words for description of Thesis Work	:	Turbulent convection; Thermal plumes; Coherent structures

SHORT ABSTRACT

The present work investigates non-standard variants (roughness-aided and tilted convection) of Rayleigh-Bénard convection (RBC) to augment heat flux for a fixed working fluid (Prandtl number = 0.7) over a wide Rayleigh number range ($10^6 \leq Ra \leq 10^{10}$). For both 2D and 3D, the study focuses on the coherent structures and heat transfer mechanisms in different configurations of Rayleigh-Bénard convection (RBC), considering thermal plumes, boundary layers, and large-scale rolls (LSR). In the smooth case, the absence of lateral direction results in the entrapped thermal plumes, which are subsequently emitted as thermal jets into the bulk. The Nusselt number (Nu) quantifies the heat carried by thermal plumes across the isothermal walls. A positive correlation between vertical velocity and temperature fluctuations is used to quantify thermal plumes. The impact of surface roughness on heat flux is investigated, highlighting the influence of irregular roughness geometries. The study identifies an onset of enhanced heat flux regime and explores the role of bulk-plume interaction and fluid mixing. With increasing Rayleigh number, transformation from a double-roll state to multiple-roll state is associated with the onset of enhanced heat flux regime for the taller configuration. On the other hand, presence of huge number of roughness elements is responsible for enhanced heat flux in the smaller configuration. Near-wall dynamics and the penetration of peaks into the thermal boundary layer are studied, revealing the significance of secondary vortices and the tendency of plume emission. The investigation extends to three-dimensional RBC with conical roughness configurations, emphasizing the role of coherent structures and intense thermal plumes in enhancing heat flux. The study provides insights into the influence of roughness on flow strength and the orientation of large-scale rolls. The effect of inclination angles in tilted RBC is examined, indicating shifts in heat transport effectiveness and early onset of turbulence with increased roughness height. In the smooth case, inclined convection (IC) enhances heat flux below $Ra = 10^8$, while above this value, normal RBC yields the highest heat flux. However, for rough surfaces, the effectiveness of IC to transport heat shifts to lower Ra as the roughness height increases, leading to an early onset of turbulence. The maximum heat flux in the smooth case is achieved at a tilt of 75° for $Ra \leq 10^8$, while in roughness cases, it depends on both Ra and the roughness configurations. The study reports a maximum increase of 25% in Nusselt number for roughness-aided tilted convection. Additionally, as Ra increases, the onset of thermal stratification is delayed in the smooth case, while an increase in roughness

height results in a similar delay in rough configurations, indicating an early onset of turbulence even at larger inclination angles.