INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	**SOUGATA BISWAS**
Roll Number	:	**126123012**
Programme of Study	:	Ph.D.

Thesis Title: **SOME ASPECTS OF CORNER VORTICES IN SEPARATED FLOWS: A THEORETICAL AND NUMERICAL INVESTIGATION**

Name of Thesis Supervisor(s)	:	**PROF. JITEN CHANDRA KALITA**
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SHORT ABSTRACT

This dissertation is mainly concerned with the theoretical and numerical investigation of corner vortices in two- and three-dimensional (2D and 3D) incompressible internal viscous separated flows; it is an endeavour to delve into certain unexplored facets of vortex dynamics. The work is broadly divided into two parts. In the first part, we establish Moffatt-likeness of the corner vortices in the lid-driven square cavity for Stokes flow and flow for moderate Reynolds numbers in the pre-asymptotic regime. The corner vortices have been resolved and documented with extreme details up to the post-quaternary level, both qualitatively and quantitatively. In the process, we also observe the self-similarity of these vortices from fractal point of view. Next, we utilize the critical point theory from the recent advances in topological fluid dynamics to gain more physical insights into the corner vortices from the perspective of the flow topology in the 2D vis a vis 3D cavity. The Poincaré-Bendixson formula is used to validate the computed results for the possible number of critical points in the cavity. We further present a detailed discussion of the vortical structures in 3D rectangular cavities including the dynamics of Taylor-Görtler-Like vortices by a rigorous topological theory. We also report the presence of ``*U*-shaped and mushroom-shaped vortex" structures in the flow field through the visualization of λ_2 isosurfaces. The second part of the work consists of the development of some novel theories on Moffatt vortices in incompressible viscous flows in bounded domains. We propose two topological equivalence classes of Moffatt vortices: one in terms of orientation preserving homeomorphism; and the other by half-saddle point structures. We further quantify the centers of vortices as fixed points through Brouwer fixed-point theorem and define boundary of a vortex as circle cell. The salient feature of this dissertation is however the development of a series of proofs establishing the finiteness of Moffatt vortices which was thought to be infinite from the time of its inception. Besides, we have listed the concerns and pertinent questions on the notion of infiniteness of such sequences and pinpointed where the assumptions of the existing hypothesis might have gone wrong. Making use of some elementary concepts of mathematical analysis and our own construction of diametric disks, we proved that the number of vortices in solid corners in a bounded domain must be finite. We further extend the above mentioned work on the finiteness of vortices to the more general situation in steady incompressible viscous flows on bounded domains.