Thesis Introduction

Jeffrey Severino
University of Toledo
Toledo, OH 43606
email: jseveri@rockets.utoledo.edu

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1 Thesis introduction

During the 1960s, the increased demand for commercialized aircraft transport introduced jet engines to support large cargo and passengers. Consequently, this rise in innovation resulted in high volume engine noise. After 1975, efforts to reduce aircraft noise eliminated the noise pollution for 90% of the population [?]. However, since the early 2000s, the advancement in noise reduction technologies has been moderately increasing, leaving a requirement for drastic improvement in aeroacoustic modeling and treatment strategies to compete with the demand for quiet subsonic flight. A turbomachine's general flow condition includes a series of axial, tangential, and radial velocity components that vary depending on the location of concern. The swirling flow between fan stages has been an area of interest due to the potential for acoustic treatment in a location previously avoided for its flow complexity, among other reasons.

In general, jet engine designers can model flow within a turbomachine with the Navier Stokes Equations, a set of partial differential equations that describe the mass, momentum and energy of a given viscous fluid. It is common in practice to utilize the Euler equations, a closely related set of PDEs that model inviscid fluid, as they provide an approximation for higher Reynold number flows where viscosity does not play a critical role. A popular approach to modeling sound propagation within a flow is to "linearize" the Euler equations, which decomposes the flow solution into a mean and fluctuating component (insert refs). Another method decomposes the flow into vortical and potential parts [[?]] In either case, this presents an initial value problem and for certain flows and domains, can obtain analytical solutions. The LEE provides a system of linear equations where the solution is a family of wavenumbers and radial mode shapes that arise from unsteady disturbances. For uniform flows in a hard wall duct , the waves are categorized as vortical and entropical waves that soley convect with the mean flow, where as the acoustic wave can propagate without damping or decay exponentially. However, for swiriling flows, the waves are partially coupled and are not easily categorized due to an additonal category of "nearly convecting" modes (Kerrebrock) and do not form a complete basis system for all wave types. Therefore, the families of waves must be found numerically [?] making the ducted acoustic propagtion in swirling flow a problem without an analytical solution but has a framework for a numerical solution.

Swirling flow has been a difficult problem to investigate in comparison to flows parallel to the wall domain of a duct [?] because of the lack of an analytical solution and thus cannot be described from a single convective wave equation. Various methods of code validation have been conducted, however, a gold standard method of code verification offers a measure of "goodness" that would strengthen the results of a numerical solution by providing a "psudo-analytical" solution which is can then be compared to the numerical solution.

The proposed research aims to determine the impact of the numerical schemes used in the swirling flow problem and how it effects the family of waves that are produced from the problem formulation so a better understanding of the acoustic phenomena as the flow under goes a compressible rotational flow. The use of the method of manufactured solutions is used as a means of ensuring the code is approximating the right equations and will check the effect of the numerical schemes on the axial wavenumbers produced

2 Issues and Concerns

Is the research gap truly stated in the introduction?

3 Planned Research

Ensure that the research problem is clearly stated and that the need for this work is explained.