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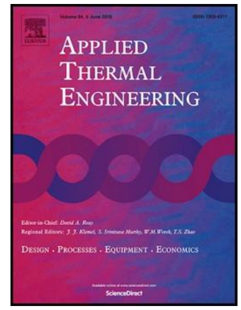

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Analytical investigation of non-adiabatic effects on the dynamics of sound reflection and transmission in a combustor

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Highlights

- By increasing cooling, the reflection is subsided, while the transmission is raised.
- The variation of transmission by cooling is much larger than the reflection.
- The response value is more altered by cooling when a subcritical nozzle is attached at the system outlet.

Abstract

Acoustics of a simplified, non-adiabatic combustor chamber, including a duct followed by a downstream exit nozzle, are considered. This system features heat transfer to the environment and, therefore involves mean axial temperature gradient along the duct and the nozzle. The effect of heat transfer on the dynamics of the acoustic reflection and transmission in the duct and nozzle is investigated analytically. These involve development of analytical expressions for the response of non-adiabatic nozzles through compact acoustic modelling and also the effective length approach. Further, an existing work on the dynamics of heat transferring ducts is extended and combined with that of the nozzles. The acoustic responses of the combined non-adiabatic system are, subsequently, characterized by analyzing the net reflection and transmission of an incident acoustic wave. The results show that heat transfer can considerably modify the dynamic behavior of the acoustic reflections and transmissions. Due to the multiple reflections in the system, the phase response features significant irregularities. It is argued that the observed modifications in the chamber acoustics can noticeably affect the thermoacoustics of the system.

Keywords: Sound reflection; sound transmission; thermoacoustic response; combustor and nozzle system.

1. Introduction

The rapidly increasing concerns about the environmental impacts of power generation sector have led to imposing stringent emission regulations [1,2]. These regulations require gas turbine and aero-engine manufacturers to achieve very low levels of NO_x emissions [2]. It is well demonstrated that lean premixed combustion technology is most efficient in reducing NO_x formation in modern gas turbine combustors [2,3]. However, the high susceptibility of premixed flames to thermoacoustic instabilities has, so far, hindered the wide application of this combustion technology [1,3]. Thermoacoustic instabilities are the result of complex interactions between the flame heat release and combustion chamber acoustics [4,5]. Occurrence of these instabilities can lead to the generation of coherent, large amplitude pressure oscillations [1, 2].