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# SURROGATE BASED DESIGN OPTIMISATION OF COMBUSTOR TILE COOLING FEED HOLES

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## ABSTRACT

Gas turbine operating temperatures are projected to continue to increase and this leads to drawing more cooling air to keep the metals below their operational temperatures. This cooling air is chargeable as it has gone through several stages of compressor work. In this paper a surrogate based design optimization approach is used to reduce cooling mass flow on combustor tiles to attain pre-defined maximum metal surface temperatures dictated by different service life requirements.

A series of Kriging based surrogate models are constructed using an efficient GPU based particle swarm algorithm. Various mechanical and manufacturing constraints such as hole ligament size, encroachment of holes onto other features like side rails, pedestals, dilution ports and retention pins etc. are built into the models and these models are trained using a number of high fidelity simulations. Furthermore these simulations employ the proprietary Rolls-Royce Finite Element Analysis (FEA) package SCO3 to run thermal analysis predicting surface heat transfer coefficients, fluid temperatures and finally metal surface temperatures.

These temperature predictions are compared against the pre-defined surface temperature limits for a given service life and fed back to the surrogate model to run for new hole configuration. This way the loop continues until an optimized hole configuration is attained. Results demonstrate the potential of this optimization technique to improve the life of combustor tile by reducing tile temperature and also to reduce the amount of cooling air required.

## INTRODUCTION

The main objective of the presented paper is to optimize the cooling flow required for a large civil engine gas turbine combustor. Typically in a civil engine, the gas turbine combustor is a dual wall structure where the outer walls are thin continuous sheets or multiple sheets welded/brazed together into continuous liners. These liners consist of a series of apertures for the cooling air to pass through and impinge onto the inner wall structure[1]. The inner wall structure can again be continuous or have discrete pieces connected to the outer wall mechanically via studs or welds. In the current study these inner walls are discrete pieces called tiles which are made up of a relatively high temperature capable material compared to the liner as they directly face the hot combustion gases. Furthermore these tiles also have thin coating of TBC to protect them from high temperatures. These tiles are held to the outer wall using studs and nuts at multiple locations. In addition to this the liner-tile assembly has a series of large holes for dumping the air into combustion zone for dilution and the cold side of each tile has a series of staggered pedestals to enhance the heat transfer. The compressed air from the diffuser passes

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