**Xu Zhang**
Faculty of Engineering and the Environment,
University of Southampton,
Southampton SO16 7QF, UK

**David J. J. Toal**[1]
Faculty of Engineering and the Environment,
University of Southampton,
Southampton SO16 7QF, UK
e-mail: djjt@soton.ac.uk

**Andy J. Keane**
Faculty of Engineering and the Environment,
University of Southampton,
Southampton SO16 7QF, UK

**Frederic Witham**
Rolls-Royce Plc.,
Bristol BS34 7QE, UK

**Jonathan Gregory**
Rolls-Royce Plc.,
Bristol BS34 7QE, UK

**Murthy Ravikanti**
Rolls-Royce Plc.,
Derby DE24 8BJ, UK

**Emmanuel Aurifeille**
Rolls-Royce Plc.,
Derby DE24 8BJ, UK

**Simon Stow**
Rolls-Royce Plc.,
Derby DE24 8BJ, UK

**Mark Rogers**
Rolls-Royce Plc.,
Derby DE24 8BJ, UK

**Marco Zedda**
Rolls-Royce Plc.,
Derby DE24 8BJ, UK

# Isothermal Combustor Prediffuser and Fuel Injector Feed Arm Design Optimization Using the PROMETHEUS Design System

*The* PROMETHEUS *combustor design system aims to reduce the complexity of evaluating combustor designs by automatically defining preprocessing, simulation, and postprocessing tasks based on the automatic identification of combustor features within the computer-aided design (CAD) environment. This system enables best practice to be codified and topological changes to a combustor's design to be more easily considered within an automated design process. The following paper presents the* PROMETHEUS *combustor design system and its application to the multiobjective isothermal optimization of a combustor prediffuser and the multifidelity isothermal optimization of a fuel injector feed arm in combination with a surrogate modeling strategy accelerated via a high-performance graphical processing unit (GPU).* [DOI: 10.1115/1.4031711]

## 1 Introduction

A typical engineering design process can involve a considerable number of design changes each of which may be followed by an assessment of the impact of those changes on multiple performance metrics. Such processes can involve multiple instances of geometry generation along with multidisciplinary simulations at varying operating conditions. The manual effort required in such design studies can be considerably reduced by employing modern design automation and optimization techniques and there are, of course, numerous examples of such techniques being applied throughout the literature. Aerofoil sections [1,2], compressor blades [3], wings [4], aircraft [5], combustors [6–8], and whole engines [9,10], for example, have all been the subject of automated design optimizations in recent years. However, the majority of engineering design optimization examples within the literature include a fundamental limitation which can limit the benefits that such automation can bring to real world problems.

As the following paper is concerned with the design of a gas turbine combustor, let us consider such a system as an example. Consider a rich burn combustion module with a set of dilution ports whose diameters are to be defined in order to improve the temperature profile at the combustor's exit. The diameters can be parameterized within a CAD package and linked to a design table or similar. A script defining the meshing strategy can be defined and used repeatedly throughout the optimization as can scripts defining the computational fluid dynamics (CFD) simulation and its postprocessing. This optimization workflow could be used to investigate various combinations of dilution port diameters and even other design issues as long as the topology of the combustion module does not change.

To illustrate the impact of a relatively simple topological change on the above workflow, let us also permit the number of dilution ports to vary. The generation of the geometry, in this instance, is not really an issue, an integer within a design table can be easily used to define the number of ports around the circumference of the combustor. However, assuming our script to

[1]Corresponding author.

Contributed by the Combustion and Fuels Committee of ASME for publication in the JOURNAL OF ENGINEERING FOR GAS TURBINES AND POWER. Manuscript received August 18, 2015; final manuscript received September 8, 2015; published online November 17, 2015. Editor: David Wisler.