The Part Thermo-Mechanical Analysis Plays in the Design of Gas Turbines.

Abstract

Modern gas turbines are designed to operate at conditions close to the material limits for many components. To allow this it is necessary to have an adequate understanding, and predictive capability, for these components. This document describes the thermal analysis process as applied to large civil aero engines design at Derby, which is also applicable to many other gas turbine applications. The document describes the individual parts of the process and explains how the data is used to support the design verification process.

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Introduction

The two main drivers in the design of new civil gas turbine aero engines are; low environmental impact and competitive advantage. Low environmental impact means a low SFC (Specific Fuel Consumption) giving low CO_2 emissions, low combustor generated emissions HC, CO and NOx etc, low noise and low manufacturing footprint. Competitive advantage means low cost of ownership (typically initial cost, fuel, maintainance and resale value). These necessitate a high overall pressure ratio and the minimum use of cooling air. This then places the following requirements on many of the components within the engine:

1) Low cost (both material and manufacture)
2) Capable of operating at high temperatures.
3) Long and reliable service lives.

Therefore to fully optimise a design it is necessary to understand the thermo-mechanical behaviour to a relatively high level of confidence.

In addition to the above, to certify the engine it may be necessary to demonstrate by analysis that certain components have an adequate life and can cope with certain failure conditions, typically understanding the thermal behaviour of these components is essential.

Analysis.

Although it is possible to solve some heat transfer problems by hand calculations the complexity of modern gas turbines general precludes this. Conjugate heat transfer is sometimes considered but it is generally too slow and inflexible for general use. Typically the analysis will use Finite Element models where the solids are represented by either '2d' or '3d' meshes and have boundary conditions applied to them.

Geometry

The geometry used in FE models is typically generated using a proprietary CADDS (Computer Aided Design and Draughting) package, typically IGES for '2d', see Figure 1, and a 'step' file for '3d' geometry, see Figure 2. The argument for '2d' vs. '3d' will depend on both how well the component can be represented '2d', the modelling fidelity required and the time available for the analysis.

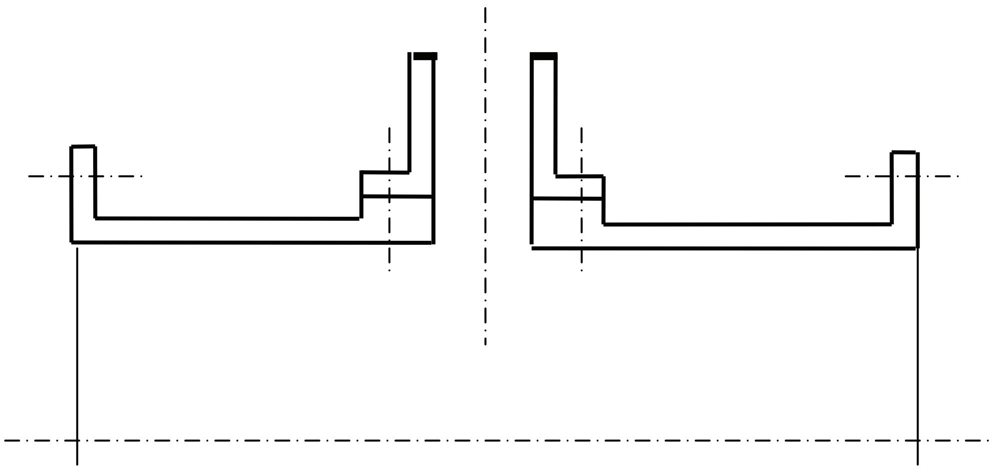

Figure 1 – '2d' Casing Geometrical Representation.