

Efficient Tip Clearance Optimisation Within E-BREAK

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Introduction to E-BREAK (Engine Breakthrough Components and Subsystems)

Previously the EIMG (Engine Industry Management Group) consortium has launched several initiatives to develop innovative technologies in order to reduce fuel burn, emissions and noise. As core engine technologies have been addressed in previous projects, E-BREAK aims to evolve and adapt sub-systems to integrate with newly developed core technologies.

The tip clearance control work package of E-BREAK aims to develop an efficient optimisation workflow for the whole engine. It shares some common features with the whole engine design optimisation within the CRESCENDO (Collaborative and Robust Engineering using Simulation Capability Enabling Next Design Optimisation) project, but will have more advanced capabilities and deal with more complex and realistic geometry.

Tip Clearance Optimisation within E-BREAK

During the preliminary design stage, engineers often want to investigate as many different designs as possible before proceeding to the detailed stage. However, due to the large number of variables in a whole engine and the time-consuming nature of 3D finite element simulations, the optimisation of one design may take weeks or even months to finish. The proposed work flow (Fig. 1) accelerates the optimisation of whole engine assemblies through an efficient medial object transformation.

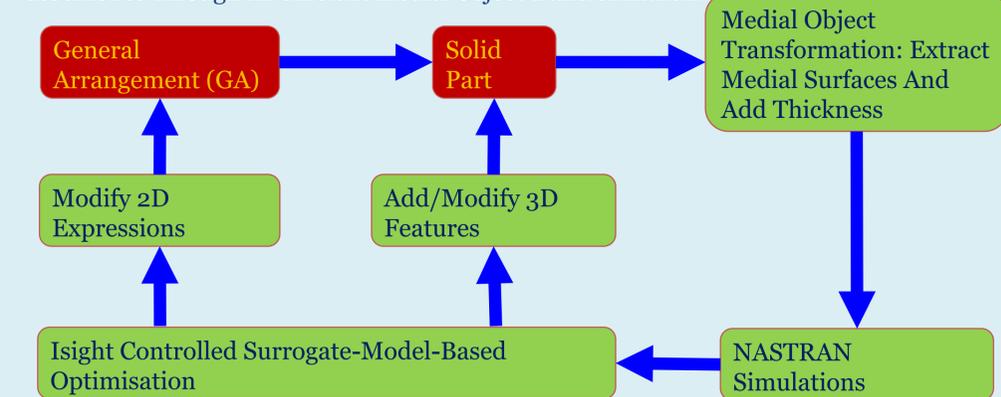


Figure 1. Proposed design flow

The process commences by creating a datum engine model by revolving a fully-parameterised general arrangement (GA) and adding 3D components from a library of user defined features (UDFs). Instead of a traditional 3D finite element simulation, a 2D medial mesh is extracted from the 3D geometry. Carrying out simulations using this mesh offers a considerable reduction in wall time with little loss in accuracy. A surrogate model based optimisation is then employed to optimise the engine geometry. The efficiency of the developed process is demonstrated through the optimisation of a realistic Trent 1000 engine for tip clearances and mass.

Parameterisation of a Realistic Trent 1000 Engine

To demonstrate the efficiency of the developed work flow. A simplified but realistic Trent 1000 engine model has been built from its GA as the datum model for optimisation. The model is representative of geometry used at the preliminary design stage. It omits inconsequential 3D features but includes key features which determine the geometry's stiffness, such as flanges, bosses, holes, lugs and struts.

A comparison of the Inter Casing (IC) using five load conditions has been carried out (Fig. 2) with the resulting displacement at 14 locations around the casing show that the root mean square error between the full 3D model and the simplified model as 12.5 % with a maximum value below 30%.

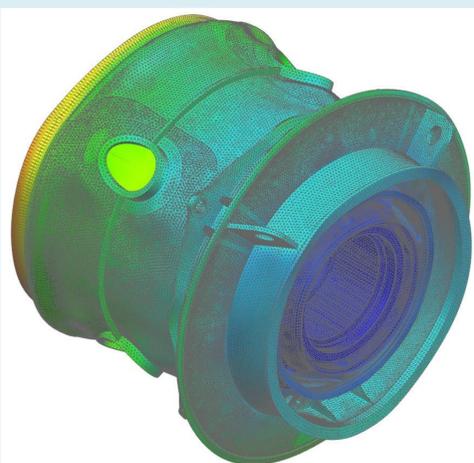


Figure 2. IC displacement under axial load

The parameterisation process is shown in Fig. 3 using the Tail Bearing Housing (TBH) as an example.

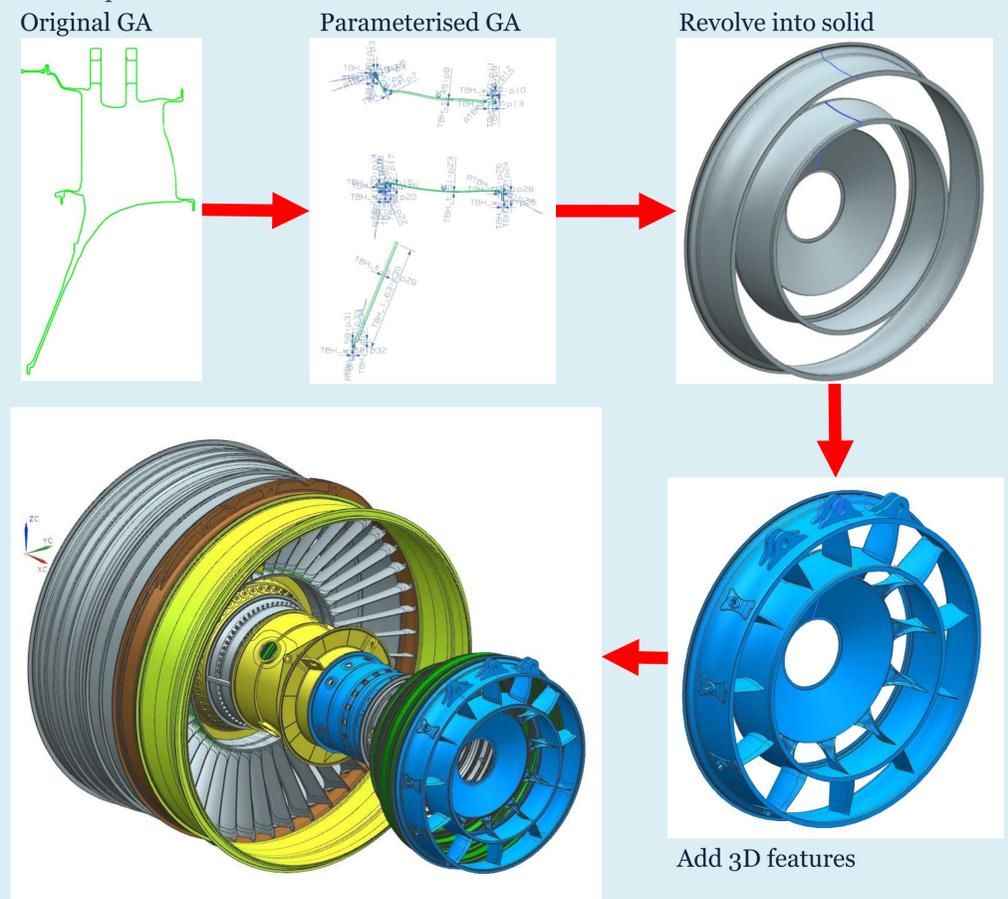


Figure 3. Parameterisation process using TBH as an example

Medial Mesh Generation

Fig.4 shows a section of the Combustor Chamber Outer Casing (CCOC) and the generated medial mesh. Simulations using the medial mesh are much faster than traditional 3D finite element simulations with comparable accuracy

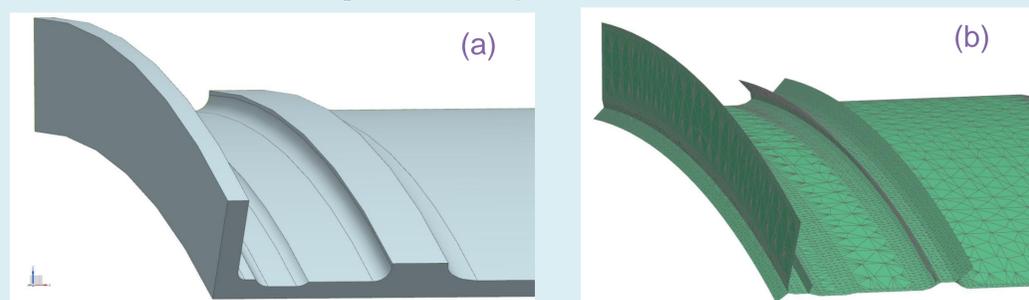


Figure 4. Medial mesh generation (a) 1/12 CCOC (b) Medial mesh

Future Work

- To develop NX Open routines to automate the medial object transformation process
- To develop a UDF library of 3D features to accelerate geometry creation
- To demonstrate the developed processes within an optimisation loop

Acknowledgements

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