

COMPARISON BETWEEN FLOWNEX[®] SE AND 3-D CFD FOR SECONDARY FLOW MODELLING IN TURBOMACHINERY

Keywords: Turbomachinery, Secondary cooling, CFD

ABSTRACT

This case study demonstrates the capability of using Flownex[®] SE as a preliminary design tool for secondary flow analysis before using detailed and computationally expensive 3-D CFD analysis. 3-D CFD Results, obtained from a CFM56-5C turbo machine secondary flow model, is compared to Flownex[®] SE's results. The study was conducted with Lufthansa in order to evaluate Flownex's secondary flow modelling capabilities.

CHALLENGE

Modelling the flow in turbomachinery is often seen as a task which can only be performed by detailed 3-D CFD analysis, requiring expensive hardware, advanced modelling techniques and experienced CFD engineers. Furthermore, time scales for detailed turbomachinery 3-D CFD analysis can become prolonged due to the complex geometry and a fine mesh required to get a sufficiently accurate solution representative of the actual physics.

BENEFITS

Various flow paths of turbomachinery can be accurately modelled using a 1-D CFD approach as opposed to 3-D CFD. Furthermore, due to the influx in new turbomachinery technology, new designs need to be assessed in the CFD environment and doing this in a 1-D environment saves engineering time and money.

SOLUTION

Lufthansa investigated the possibility to use Flownex[®] SE in the secondary flow analysis of a CFM56-5C turbomachine. Results were obtained from a detailed 3-D CFD analysis and Flownex showed good agreement to the 3-D CFD results to within 10%. Solving time of the Flownex[®] SE models were in a matter of seconds whereas the CFD models were in the order of hours.



Lufthansa Technik



Flownex is able to accurately predict flow and heat transfer in secondary air systems, whilst reducing model setup and execution time substantially compared with 3D CFD.



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INTRODUCTION

Using a 1-D modelling approach to secondary flow analysis for turbomachinery saves engineering time and money. A study was recently done by Lufthansa and Flownex® SE in order to compare detailed 3-D CFD results with Flownex on the secondary cooling flow through the Low-Pressure Turbine (LPT) first stage stator vane of the CFM56-5C turbomachine.

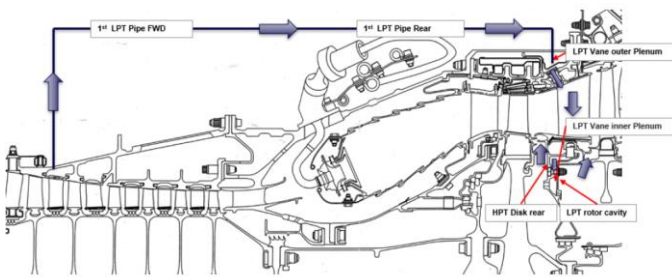


Figure 1: LPT stage 1 stator vane secondary cooling airflow path

METHODOLOGY

A Flownex® SE model, shown in Figure 2, was set up to model the secondary cooling airflow path from the 1st LPT pipe position up to the respective cavities where flow leaves the vane assembly.

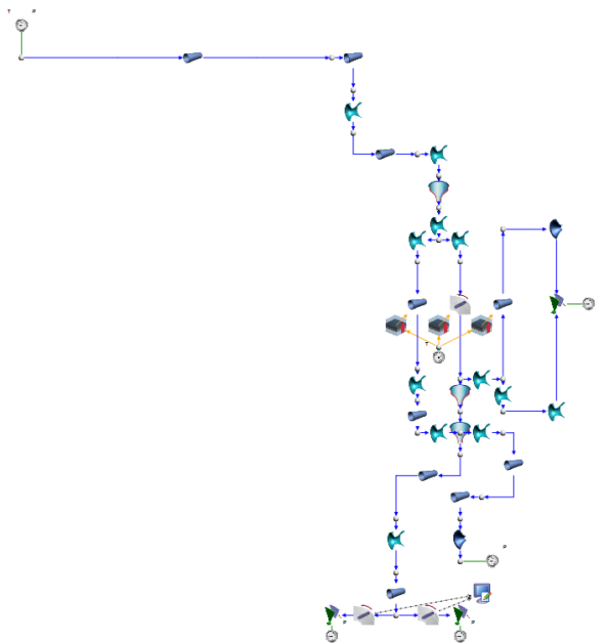


Figure 2: Flownex® SE model of the secondary flow path

The model's boundary values represented the inlet static temperature and pressure, as well as the cavity static pressures supplied from the 3-D CFD analysis results.

The Flownex® SE model shows only 1 flow path, but the applicable "Number in parallel" values were specified in order to model the flow through all 96 vanes. Composite heat transfer elements were used to model the heat transfer from the vane surface to the fluid, with the material assumed to be a coated metal having a specified conductivity.

The mass flow resulting from the outer pressure difference and geometric flow resistance was used for comparative purposes, as well as the static pressures and temperatures results calculated at the other network positions obtained from Lufthansa.

RESULTS

By using boundary conditions obtained from 3-D CFD results, Flownex® SE calculated a mass flow rate of 1.84 kg/s. This correlates well with the expected mass flow rate of 2 kg/s from the Lufthansa estimation. The same went for the pressure drop results.

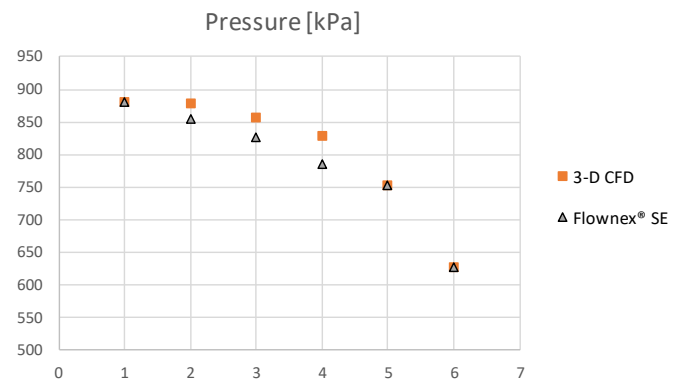


Figure 3: Pressure drop results in the secondary airflow path

CONCLUSION

Simulation time for the Flownex® SE model to solve was a matter of seconds which provided quick results for comparison to the 3-D CFD results. Results obtained from Flownex® SE proved to provide a high degree of accuracy when compared to expected results and 3-D CFD results.

Flownex® SE is now being used by Lufthansa as part of their turbomachinery design's software suite. This enables them to quickly do various simulation runs for varying sensitivity studies and evaluating the performance impact on the engine with consideration of wear and tear – saving them valuable engineering time and money.