turbodesign optima

information

Enables 3D Multi-Point/Multi-Objective Optimization by Coupling Inverse Design, CFD and Different Optimization Schemes, such as Design of Experiments, Response Surface Modelling and Genetic Algorithms

Inverse Design Based Optimization Versus Conventional

Using the blade loading distribution as design parameter in 3D optimization and generating the blade shape by using 3D inverse design offers many advantages as compared to optimization based on parameterizing the blade geometry. The main advantages are:

- Using just 6-8 design parameters it is possible to cover as much design space as 30-100 parameters using direct design parametrization of blade geometry.
- The loading distribution fixes the specified work distribution and pressure ratio. So there is no need to use a constraint in the optimizer slowing down the convergence process.
- The objective function Y=F(Xi) correlating the input parameters to the output performance has a simpler mathematical expression as the loading distribution parameters (Xi) relate more directly to performance parameters Y such as profile loss, secondary flow loss, tip clearance etc.
- Results of optimization is a loading distribution which has generality and can be applied to other cases with ease by using the inverse design method only. Optimization is used as know-how generator and not as a design method.

Different Optimization Strategies (Workflows)

TURBOdesign Optima offers different optimization strategies (workflows) as outlined below:

1. TURBOdesign1 + MOGA: This enables multi-objective optimization at the design point using the performance parameters related to surface pressure or velocity and geometry computed by TURBOdesign1.

2. TURBOdesign1 + TURBOdesign cfd + Optimizer: This approach uses TURBOdesign1 as geometry generator and TURBOdesign cfd for performance parameters such as loss, cavitation or noise parameters at design or off-design.

3. TURBOdesign1 + TURBOdesign cfd + DoE + RSM + MOGA: This approach couples TURBOdesign Suite with Design of Experiments, Response Surface Modelling and Multi-Objective Genetic Algorithm.

4. TURBOdesign1 + 3rd Party CFD/FEA + DoE + RSM + MOGA: This approach is similar to work flow 3 but allows the use of third party CFD/FEA codes.

Workflow1: TURBOdesign1 + MOGA

This approach uses outputs from TURBOdesign1 to compute the performance parameters related to geometry or flow field. Parameters such as secondary flows, tip clearance, profile losses, diffusion, NPSH, tonal noise, lean angle, volume of blade, cross section area, throat area etc.

Application to Centrifugal Compressor

This approach was applied to the optimization of a centrifugal compressor impeller in which secondary flows and lean angle were used as objective functions, while throat area was used as a constraint. The resulting Pareto Front is shown in Fig.1.

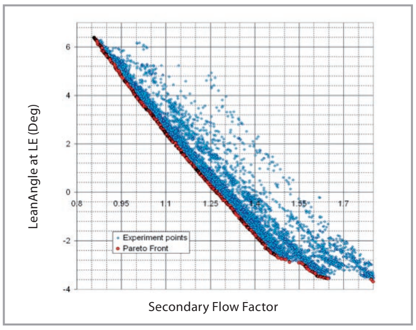
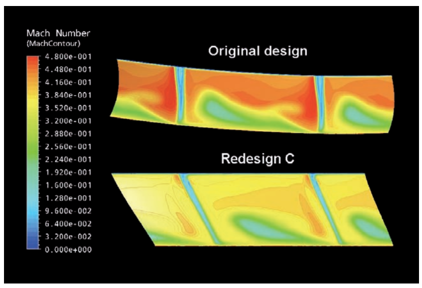


Fig. 1: Pareto front for centrifugal impeller.



Workflow 2: TURBOdesign1 + TURBOdesign cfd + Optimizer

A schematic diagram of this approach is shown in Fig. 3.

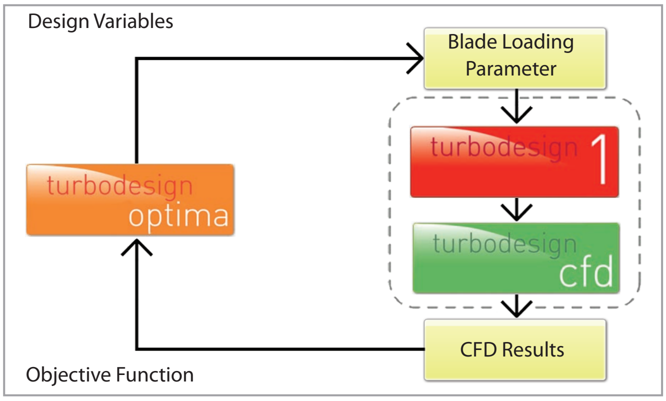


Fig. 3: Schematic of Workflow 2.

In this approach different optimization methodologies can be employed such simulated annealing or genetic algorithm.

Application to Pump Impeller

The efficiency of a mixed-flow pump impeller, with a specific speed of 1350 (m3/min, m, min-1), was optimized with constraints on the suction performance using such an approach and using Simulated Annealing as optimizer. The initial and final loading are shown in Fig 4.

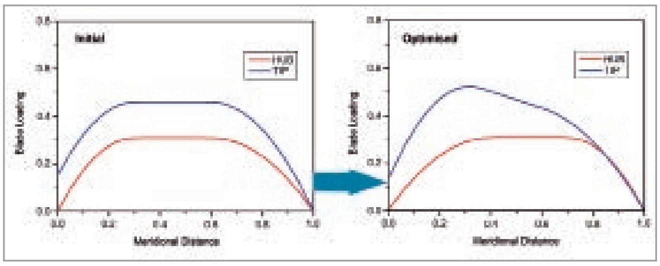


Fig. 4: Initial and Optimized blade loading.

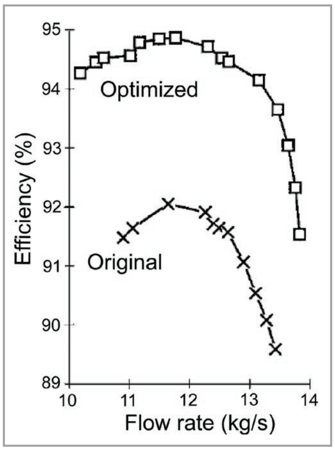


Fig. 5: Efficiency comparison for the optimized pump impeller versus original.

Workflow 4: TURBOdesign1 + 3rd Party CFD + DoE + RSM + MOGA

A schematic diagram of this approach is shown in Fig. 6.

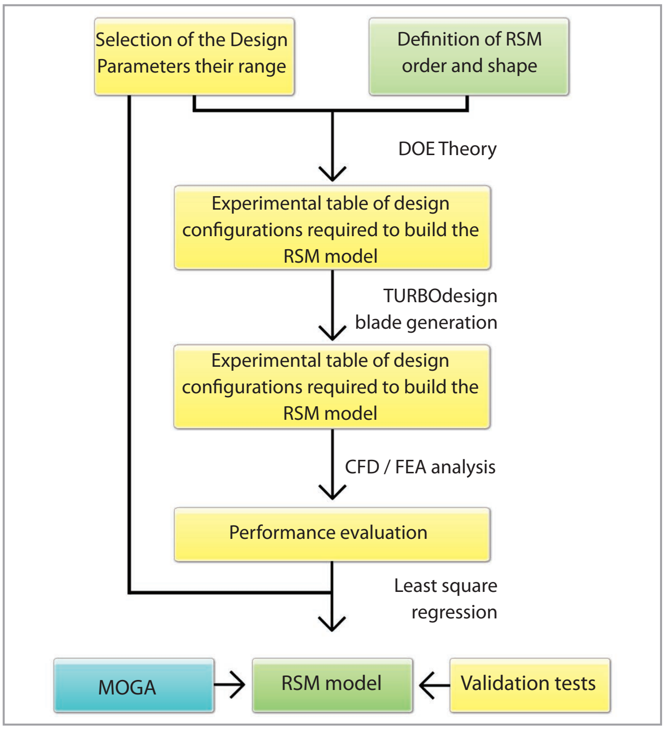


Fig. 6: Schematic of Workflow 4.

Application to axial compressor stage

- 5 design parameters in total were used for the whole stage
- 11 different performance parameters to define design and off-design stage performance
- 28 configurations in total were analysed
- R2 value of 98 - 99% for the RSM

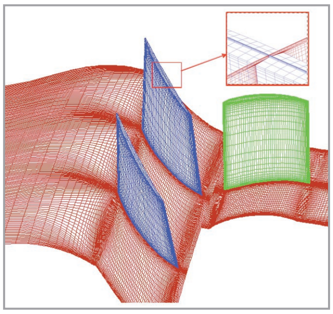


Fig. 7: Computational mesh for axial compressor stage.

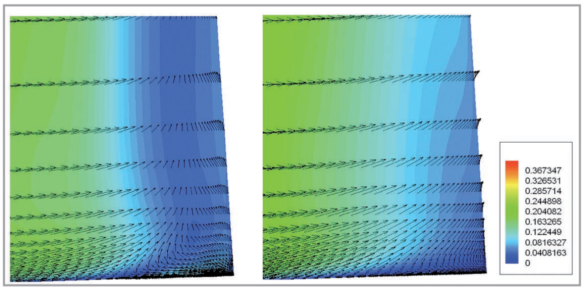


Fig 8: Comparison between original and optimized flow in stator.

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