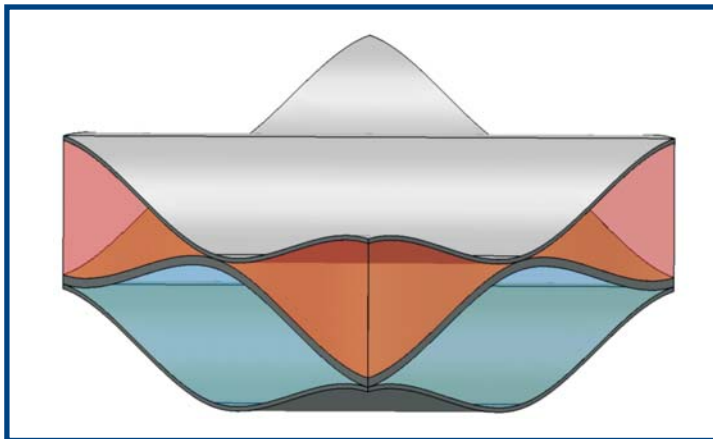




Optimization of Micro Turbine Compact Heat Exchanger

Automatic Integration in the Design of a Microturbine Compact Recuperator

The present work describes an automatic approach for the optimized design of cross-corrugated compact heat exchangers, that integrates a commercial CAD software, CFD analyses and an advanced Multi Objective Genetic Algorithm optimization methodology.



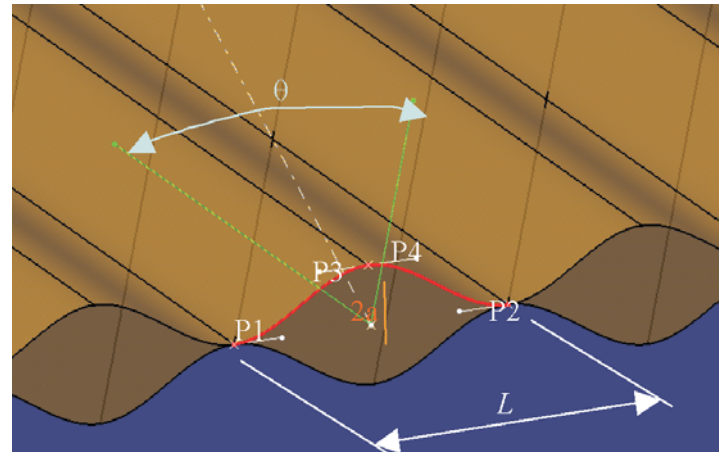
3D CAD model of Heat Exchanger

Methodology

The current interest for rapid prototyping techniques leads to the requirement of a fast passage between design ideas and final solution. For this purpose, some widespread industrial codes are linked sequentially in this work to obtain an automatic procedure for the recuperator design and optimization. The utilized software tools are CATIA for the geometric parameterization, ANSYS ICEM-CFD for the computational grid generation, cfx-pre for the fluid-dynamic model setup, cfx5solver for the numerical solution achievement and cfx5post for the post-processing and calculation results analysis.

The complete automation chain is managed by the optimization tool modeFRONTIER.

Points P1, P2, P3 and P4 defines the Bezier curves which define the shape of the extruded virtual profiles forming the flow channels. The half height of the channel is given by



Parametrization of the geometry

parameter a , while its width is defined by parameter L . The extrusion inclination of the upper and lower plates are controlled by the parameter q . Changing the parameter values, various different geometries can be easily produced. The geometry generated for a set of the parameters can be exported and subsequently natively loaded by the software ICEM-CFD where a structured grid is generated.

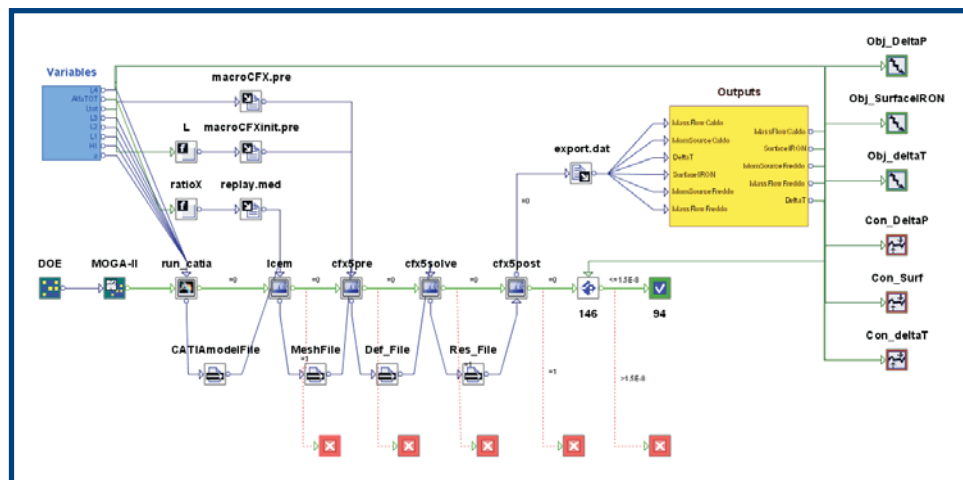
The grid is then imported into the preprocessor cfx5pre where fluid characteristics and boundary conditions are automatically defined. In this step important parameters for the numerical solution, such as convergence criteria and maximum number of iterations, are also set.

The case file exported by the cfx5pre module is processed by the cfx5solve one, that solves fluid and thermal equations. Finally the results are post-processed by the cfx5post code to obtain the not-dimensional synthetic data for performance evaluation. The capabilities of the CEL language of the CFX code has been exploited in the computing step of the automatic design approach, to couple the periodic boundaries setup and the definition of the source terms in momentum and energy equations.

Calculations have been performed for a 90° cross-sinusoidal geometry with typical run conditions of microturbines recuperator, corresponding to low values of Reynolds



case history

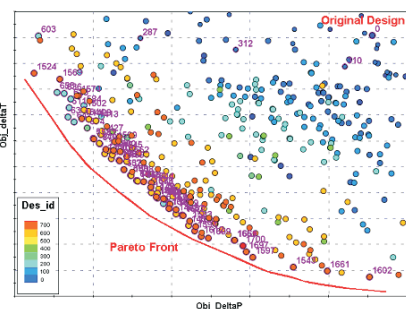


losses (Obj_DeltaP) and the differences between the bulk temperatures of the hot-gas and cold-air domains (Obj_DeltaT). This last index is a measure of the efficiency of the heat exchanger.

The original design chosen is a 60° cross-sinusoidal profile geometry with the highest thermo-dynamic performances found in literature.

All the objectives has been nondimensionalized on the bases of the original geometry results.

numbers and Prandtl number = 0.7 to compare the obtained results with literature data.



The computed designs in the space of the three objectives (each one to be minimized) after 700 Designs

The three different objectives are the minimization of the total surface (Obj_SurfaceIRON, which is directly connected to the weight and the cost of the recuperator), the pressure

Results

The result of a Multi Objective optimization is a Pareto front of non-dominated solutions.

By means of the Multi Criteria Decision Making of modeFRONTIER, the best geometry with higher performances

	ΔP	ΔT	Surface
Optimized design	-2%	-3%	-1%

compared to the original one has been chosen.

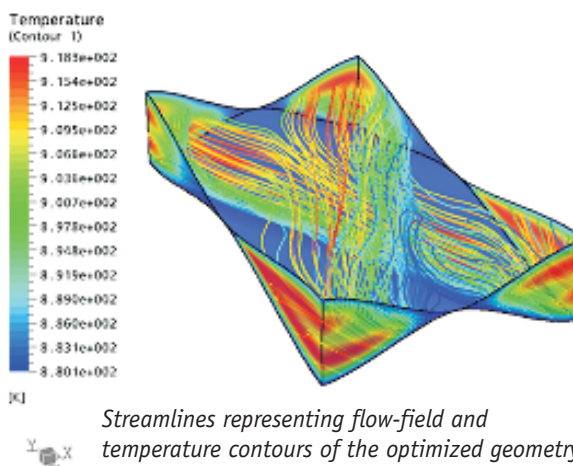
- Lower pressure losses;
- Lower difference between the bulk temperatures of the two fluids which corresponds to a higher efficiency of the heat transfer;
- Lower surface which influences the total weight and the total cost of the recuperator.

modeFRONTIER

modeFRONTIER provides a powerful and easy to use solution to include CAE software into an integrated design chain where CAD, FEM, CFD, cost prediction and Six-Sigma design are used simultaneously and in a distributed environment to push the envelope in product development.

modeFRONTIER includes a wide range of numerical methods for DOE, Robust Design, Optimization and data-modelling. A powerful post-processing and easy to use process flow integration greatly enhance both the engineers as well as the decision maker capability automating frequent tasks while filtering only useful information.

www.modefrontier.com



Streamlines representing flow-field and temperature contours of the optimized geometry.