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MULTI DISCIPLINARY OPTIMIZATION OF THE INTERNAL COOLING CHANNELS OF HP TURBINE BLADES

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ABSTRACT

The paper presents a procedure for the multidisciplinary optimization of turbomachinery components by means of the Conjugate Heat Transfer method (CHT) and Finite Element stress Analysis. The method makes use of a Genetic Algorithm (GA) requiring the analysis of a large number of geometries. However the large computational cost of a CHT analysis results in a prohibitive computational effort. The procedures that have been introduced to reduce it to acceptable values are presented.
The first step has been the development of a more elaborate optimization system, in which a large part of the CHT analyses are replaced by approximated predictions by means of a metamodel (Fig. 1). The use of an Artificial Neural Networks and Radial Basis Functions as metamodel, has been tested and the merits of the respective methods are compared.

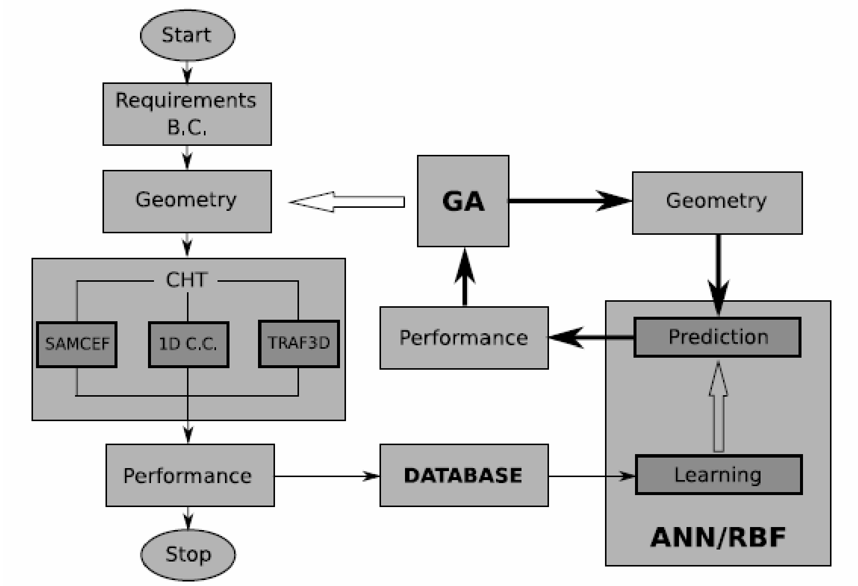

Fig. 1 Schematic view of the optimization algorithm

The second improvement is by defining a single objective function for a multiobjective optimization. It is shown that this leads to a much more targeted convergence requiring a much smaller number of expensive performance evaluations.
The method is illustrated by the Aerothermal optimization of the first stage rotor blade of an axial HP turbine operating at a very high inlet temperature (Fig. 2). A CHT analysis of each newly created geometry provides the input for the subsequent thermal stress analysis. Both temperature and stress distributions are input to the Larson-Miller material model to predict the lifetime of the blade. It is shown how this procedure, based on CHT calculations, a Genetic Algorithms and a metamodel allow defining the position and diameter of the cooling channels, leading to the maximum lifetime of the blade while limiting the amount of cooling flow.

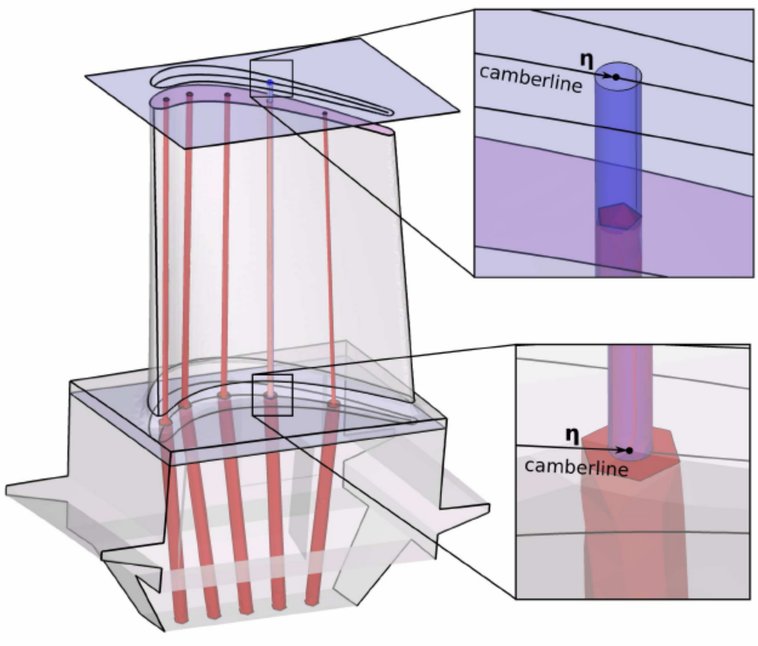

Fig 2 Definition of cooling channel position

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