OPTIMISATION OF A THREE-DIMENSIONAL AXIAL PUMP USING AN ARTIFICIAL NEURAL NETWORK, A GENETIC ALGORITHM AND A NAVIER-STOKES SOLVER

Olivier Tuot, France
Supervisor: R.A. Van den Braembussche

The optimization methods have witnessed important developments during the last years, providing more efficient turbomachines in a much easier way than the customary trial and error approach. The flow in axial compressors is per se three-dimensional, turbulent and unsteady. Therefore, the aerodynamic design is difficult due to the complexity of the flow. The progress in the optimization is basically due to the availability of powerful 3D Navier-Stokes solvers. The future trend to design three-dimensional turbomachinery pumps try to imitate the behavior of the human intelligence. The processing of the large data provided by 3D Navier-Stokes solver is carried out using artificial neural networks and genetic algorithms.

The aim of the project is the optimization of an helico centrifugal pump (IFP Poseidon family). The first step was to define a good parametric representation of this pump. What parameters are necessary and relevant for the efficiency had to be found. This definition is sufficiently general to generate a large variety of pumps with a low number of free parameters. Then, the existing 3D Navier-Stokes solver was united with an interface suitable to the geometric model in a full automatic procedure. The second step was to create a database, which contains enough cases with good, medium and ``bad'' efficiency. This database is built by a ``large'' number of cases, which cover different geometric configurations. The final step has been the use of an artificial neural network (ANN) substituting the 3D Navier-Stokes solver as an intelligent interpolator to predict the performance. The ANN learning phase has been performed using a relevant database by Standard Back-propagation of the error. During the optimization cycle performed by a genetic algorithm (GA) and the ANN, the GA has provided an optimum geometry, which has been analyzed by a Navier-Stokes flow solver and added to the database. The procedure is fully automatic (coupling geometry generation, ANN prediction, GA guess and NS). The systems ends when the Navier-Stokes solver confirms that the optimum geometric configuration has been found.

It is concluded from the last optimization cycles than the fitness remains constant for the NS solution as well as for the ANN prediction. Nevertheless, the geometry continued to evolve from one cycle to another one. It shed light on the definition of the fitness which allows a balancing between penalties and on the population initialization at each optimization cycle. In the future, instead of starting from scratch, the initialization could be done using the best case present in the database, consequently a good criteria has to be found to avoid local optimum. In a spite of these drawbacks, lots of improvements in the design were made. Separation, providing low turning and lots of losses, have been eliminated, the stage design has been modified to improve the efficiency and especially to account for a multi-stage environment.

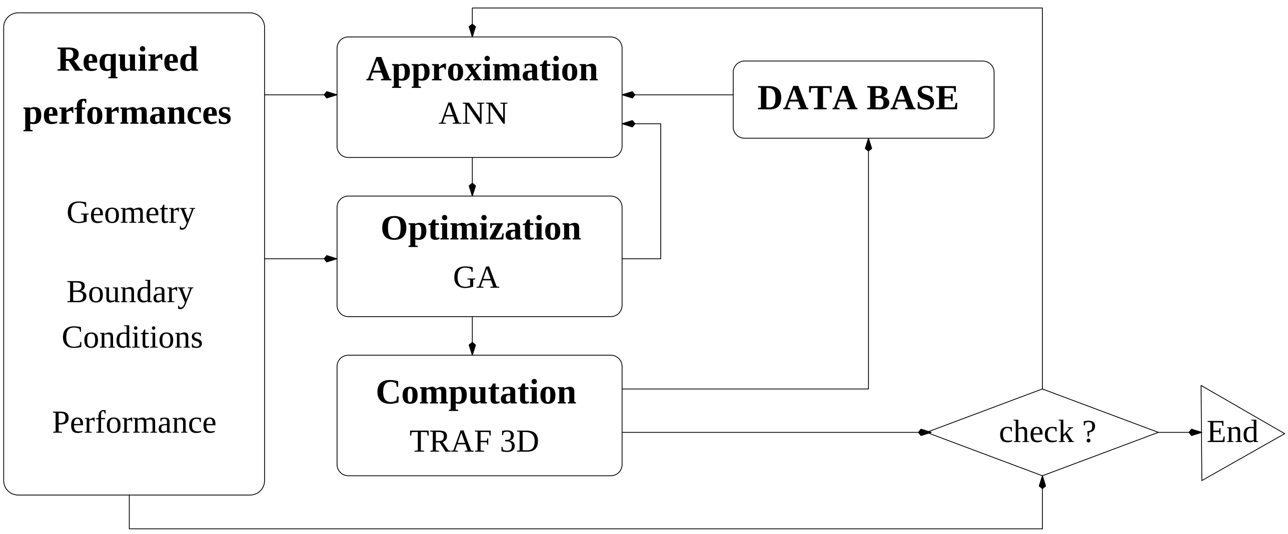

Figure 1: Design optimization method algorithm