8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

MULTIOBJECTIVE HEAT TRANSFER OPTIMIZATION IN CORRUGATED WALL CHANNELS BY HYBRID GENETIC ALGORITHMS

*** Diego Copiello**[1]**, Giampietro Fabbri**[2]

[1] Università di Bologna,
Dipartimento di Ingegneria Energetica,
Nucleare e del Controllo Ambientale,
II Facolt di Ingegneria,
via Fontanelle 40, 47100, Forlì
Italy
diego.copiello@unibo.it

[2] Università di Bologna,
Dipartimento di Ingegneria Energetica,
Nucleare e del Controllo Ambientale,
via Zannoni 45/2, 40134 Bologna,
Italy
giampietro.fabbri@mail.ing.unibo.it

Key Words: *Multi-Objective optimization, Genetic Algotithms, Neural Networks, Wavy Channel.*

ABSTRACT

In the present work, we describe the maximization of the heat transfer in a channel composed by a smooth and a corrugated wall. Moreover, we are also interested in the minimization of the pressure drop leading to a multiobjective formulation of the optimization problem. In other words, we aim to find the so called *Pareto front* constituted by all that geometries whose maximize the Nusselt number and, at the same time, minimize the normalized pressure drop. To this aim, a hybrid multiobjective algorithm has been developed and it is constituted by a genetic algorithm and a neural network trained to speed up the convergence of the optimizer. In particular the multiobjective genetic algorithm employed is the SPEA2 developed by Zitzler et al.[1]. During the reproduction, offspring are generated from the previous populations by means of a crossover operator. In the present paper, we suggest a new crossover operator based on the definition of the fitness function of the SPEA2 and on the directional genetic operator developed by Poloni et al.[5]. Results obtained on benchmarks showed good performances in terms of robustness and convergence speed compared to other genetic operators. To further increase the robustness of the optimization procedure, after a certain number of generations a Dynamic Threshold Neural Network[2] has been trained by means of individual evaluated so far in order to approximate the two objective functions. Thereafter, the two functions are joined together by means of a weighted summation[3] and the resulting function is optimized by a conjugate gradient algorithm. The optimizer has been successfully tested on many mathematical problems[4][5]. Moreover, since the test case proposed by Poloni et al.[5] demonstrated to be the hardest to solve, it has been used to determine the optimizer parameters such as the number of elements of the populations.
The multiobjective hybrid algorithm has been used to optimize a wavy channel. In particular, the geometry analyzed is composed by two walls, one smooth and thermally insulated and the other wall is corrugated and crossed by a heat flux q'' which is uniformly imposed on its external surface (see Fig. 1). The corrugation thickness $f(x)$ is described by a fifth order polynomial function where its

derivative at the inlet and outlet boundaries assumes the same value. Therefore, $f(x)$ is univocally determined by four equidistant points and their position has been used as inputs for the optimizer.
Between the two walls, a coolant fluid passes through in laminar flow in the x direction. To analyze the heat transfer problem considered, the hypotheses of velocity and temperature profiles fully developed has been made. In addition, the system has been considered in steady state. Therefore, only a portion of the heat exchanger can be solved imposing periodical boundary conditions to the system of governing equations at inlet and outlet boundaries. Moreover, due to the homogeneity in the normal to plane (x, y) direction, the heat transfer performances of the channel can be studied by only determining the velocity and temperature distributions on plane (x, y). The problem here analyzed has been solved by means of a control volume finite element code developed by one of the authors.
Figure 2 shows the Pareto front related to the case of fluid with Reynolds number equal to 500 and Prandtl number equal to 5. The analysis of the wall profiles which belongs to the Pareto frontier allows interesting considerations. In fact, there are several mechanisms that influence the heat transfer in such a geometry(i.e. the extension of the solid-liquid heat exchange surface, the presence of eddies, etc) and they all contribute also in the increment of the pressure loss in different ways. Thereafter, the analysis of the Pareto front permits to detect and evaluate which heat transfer mechanisms are present.

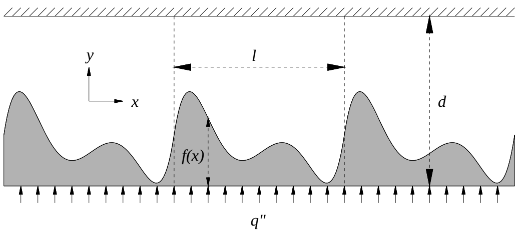

Figure 1: Geometry.

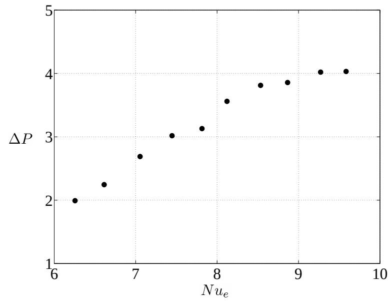

Figure 2: Wavy channel Pareto front.

REFERENCES

[1] E. Zitzler, M. Laumanns, L. Thiele. “SPEA2: Improving the Strength Pareto Evolutionary Algorithm”, Computer Engineering and Networks Laboratory, ETH Zurich, 2001.

[2] C. Cheng-Chin, F. Hsin-Chia. “On the classification capability of a dynamic threshold neural network”, *International Journal of Neural Systems*, Vol **5**, 1994.

[3] K. Deb and T. Goel. “A Hybrid Multi-objective Evolutionary Approach to Engineering Shape Design”, *First International Conference on Evolutionary Multi-Criterion Optimization*, Springer-Verlag, 2001.

[4] K. Deb, S. Agrawal, A. Pratab, T. Meyarivan,A Fast Elitist Non-Dominated Sorting Genetic Algorithm for Multi-Objective Optimization: NSGA-II, *Proceedings of the Parallel Problem Solving from Nature VI Conference*, Springer. Lecture Notes in Computer Science No. 1917, Paris, 2000.

[5] C, Poloni , A. Giurgevich, L. Onesti, V. Pediroda, Hybridization of a multi-objective genetic algorithm, a neural network and a classical optimizer for a complex design problem in fluid dynamics, *Computer Methods in Applied Mechanics and Engineering*, Vol **186**, 2000.