Aerodynamic Optimization at SAAB

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At Future Products and Technology, SAAB, Linköping, the wing-opimization code syn87 has been used for aerodynamic design since the beginning of 1996. The code which was originally developed by professor Antony Jameson, Stanford University, (reference 1) consists briefly of the following three parts:

1. Solver for the 3D Euler equations
2. Solver for the 3D adjoint equations to the Euler equations
3. Gradient based optimization algorithm, using the solutions from 1 and 2 above

The algorithm, which is based on control theory, has proven to be superior to earlier methods in which gradients were computed by means of finite differences especially if a large number design variables is desired.

A new general optimization code based on the algorithms in syn87 has during 1996-97 been developed at SAAB and the department of Mathematics, Linköping University in cooperation. This project is a sub project in the Swedish Network in Applied Mathematics (NTM).

From industrial point of view it is important that the optimization code can handle general cost functions, constraints and complex 3D geometries. The original version of syn87, which was aimed at single wing optimization, didn't have this possibility. An example of a drag minimization at constant lift, using syn87, is shown in figures 1 and 2. The ONERA M6 wing was chosen as the initial wing.

The new optimization code is instead based on structured multi block grids and hence aerodynamic optimization of general 3D objects can be performed. To reduce the execution time acceleration technique, similar to that of syn87, such as local time stepping and multigrid acceleration have been applied.

Since different cost functions and constraints, on both the flow solution and the design variables, will be used in the future, the modularity of the program has high priority. Of importance is also the possibility to extend the program to new applications such as coupled structure/fluid optimization. We have hence to a large extent chosen an object oriented language (C++) with exception for a few time consuming subroutines which were written in FORTRAN in order to ensure a high efficiency on vector and parallel computers. The program has been tested and validated on different computers like SGI work stations and the super computer Cray C90.
The basic optimization methods as well as results and comparisons from optimization studies, using both the original syn87 and the new code, will be discussed at the conference.

1. 20% at the Department of Mathematics, Linköping University

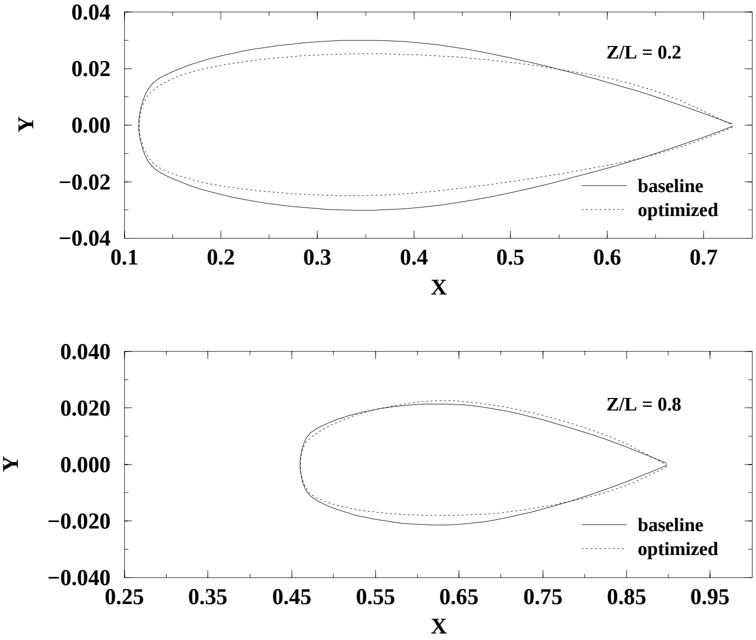

Figure 1. Initial wing (Onera M6) and optimized wing, at two span stations, using drag minimization at constant lift for a free stream mach number of 0.84.

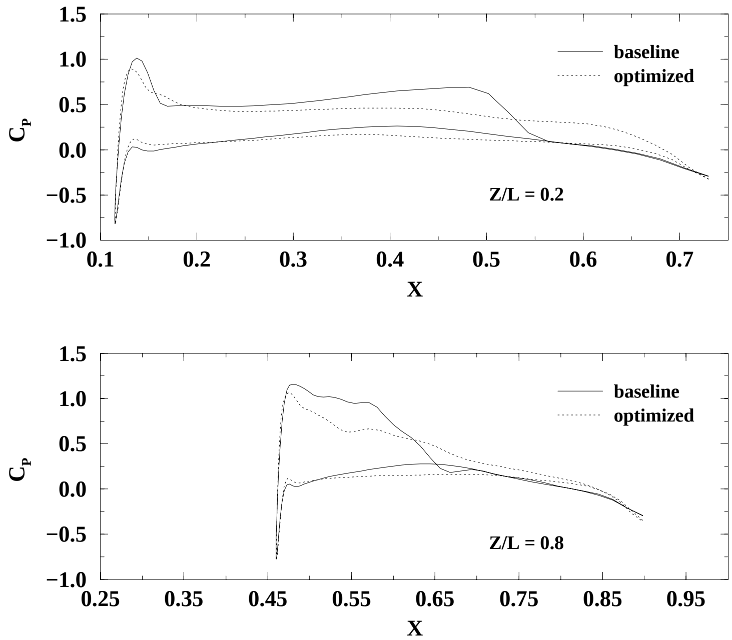

Figure 2. Pressure distribution over the Onera M6 wing and the optimized wing.

References.

1. A. Jameson, Aerodynamic design via control theory, J. Sci. Comp., 3 (1988), pp. 233-260.

2. P.Weinerfelt, Aerodynamic optimization using control theory and surface mesh points as control variables, Report FAU-97.044, SAAB, Linköping.