APPENDIX A
Review of the GENESIS Software

After obtaining the demonstration version of the commercial FEA and structural optimization software GENESIS, a variety of example problems were undertaken. A discussion of the capabilities and limitations of GENESIS based on these experiences is given.

A.1 Introduction

GENESIS by VMA engineering performs structural design optimisation using sensitivity based mathematical programming and finite element analysis. The topology of the design remains fixed but element properties (sizing optimisation) and nodal locations (shape optimisation) can be altered. GENESIS comes with a graphical pre and post-processor called FEMB that stands for Finite Element Model Builder. The FEMB user interface allows geometry based model building, automatic meshing, assignment of the design optimisation parameters, visualisation of the optimisation variable histories and visualisation of the FEA results.

A.2 Capabilities

The mathematical techniques employed by GENESIS take full consideration of any structural constraints set by the user. As such, a feasible design will be achieved whenever possible. The constraints along with the objective function are all derived from the chosen FEA ‘responses’. These responses can be stress, deflection, natural frequencies, vibration modes, heat transfer rates, mass, ply failure index (for laminated composites) and others. Objective functions and constraints are built up from any of these responses with user-defined equations and external functions written in either FORTRAN or C++.

To provide rapid convergence, all the analysis methods are linear and partial derivatives for all of the design responses are evaluated. However, fully non-linear constraints and objective functions are allowed and provide good results. Also, constraints on multiple load cases are easily assigned and taken into the optimisation process.

GENESIS runs directly from an ASCII command file that is created either by the user or by the FEMB/GENESIS interface. As such, some degree of integration with other codes is possible by writing such files in the external software.

A special mode of operation supports FE Model updating for matching experimental data to the FEA results. Here, element stiffness and mass properties can be altered to match static test data, buckling loads and natural frequencies, etc. This type of activity is not directly relevant for structural optimisation but it may be useful in other areas.

A.3 Limitations

One major limitation with GENESIS is the absence of any linear buckling analysis or optimisation[1]. Local buckling can be constrained by manually assigning buckling stress equations but this is not ideal for panel structures with a complex geometry or orthotropic materials.

Discrete design variables can not be assigned to GENESIS models using the FEMB user interface. One use of discrete variables would be to define allowable sheet thickness values or beam cross-sections. The Design Optimization Tools (DOT) software that performs the mathematical optimisation for GENESIS is able to handle discrete design variables. For this reason, it may be possible to alter the ASCII data file such that discrete values are used. However, this is not documented in the material sent with the demonstration software.

[1] The inability to perform linear buckling optimization excluded the use of GENESIS from the spoiler sizing optimization studies reported in Chapter 4.

A US regulation forbids the export of ‘composite design optimisation tools’ so the copy of GENESIS obtained has this aspect disabled. This regulation relates specifically to military organisations and a special licensing agreement can be obtained for university or other non-military research upon application.

Another limitation with GENESIS involves shape optimisation. It is necessary to define the design space of possible shapes by linear combinations of nodal perturbation vectors. One type of nodal perturbation vector is defined by ‘DVGRID’ (design variable to grid) relationships. The use of DVGRID’s restricts the allowable geometry to some extent but careful use of the software would eliminate any major problems. However, the generation of the DVGRID’s is not an efficient process and some skill and experience is required. The nodal perturbation vectors can also be assigned by so called ‘natural basis vectors’. By this method, the displacement results from linear static, natural frequency or thermal analyses are used. This holds more promise for complex models and has a similarity with Biological Growth Structural Optimisation (BGSO) by Querin & Lencus (1998).

The buyer of GENESIS has no access to the internal routines. This means it is impossible to call analysis or optimisation modules in alternate ways. Hence, the use of GENESIS as a research tool is some what reduced.

A.4 Conclusion

The capabilities and limitations of GENESIS have been discussed. It was seen that GENESIS performs well at gradient based shape and sizing optimisation and that the FEMB user interface is an effective pre and post-processor. GENESIS does not include linear buckling analysis or optimisation and a special license is needed to utilise the composite design optimisation capabilities.

References

Querin, O.M., Lencus, A., "Optimisation of Structures Subject to Multiple Load Cases Using Biological Growth Laws", *Proc. ACSO 98'*, pp. 251-258, Sydney, Australia, 1998.