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

PUCK FAILURE CRITERION AS CONSTRAINT IN THE OPTIMIZATION OF LAMINATED COMPOSITES

***Rafael H. Lopez[1], Marco Luersen[2] and Eduardo S. de Cursi[3]**

[1] INSA - Rouen
76860 Saint-Etienne du Rouvray CEDEX
France
rafaelholdorf@gmail.com

[2] UTFPR
Av. Sete de Setembro, 3165
Curitiba/PR - 80230-901
Brasil
luersen@utfpr.edu.br

[3] INSA - Rouen
76860 Saint-Etienne du Rouvray CEDEX
France
eduardo.souza@insa-rouen.fr

Key Words: *Puck Failure Criterion, Genetic Algorithm, Laminated Composite Optimization*

ABSTRACT

A laminated composite can be tailored accordingly to the designer's needs, being orientation of the laminas, thickness and number of layers usually the design variables. In order to achieve the best results, optimization techniques have been developed. Among them, the genetic algorithm (GA) has been widely used to pursue the optimization of a given composite structure (Le Riche and Haftka, 1995).

Laminated composites failure criteria may be classified into three groups: limit or non-interactive theories (maximum stress, maximum strain); interactive theories (Tsai-Hill, Tsai-Wu); and partially interactive or failure mode-based theories (Puck).

Regarding failure criteria, it seems surprising that many scientists, when implementing failure criteria for brittle composites, decided to follow the yield criteria of von Mises or Hill which hold only for ductile materials (Puck and Schürmann 1998). It seems much more appropriate to use the failure criteria of Mohr as guidelines, these having been developed for materials that exhibit brittle fracture characteristics. A criterion which accomplished it is the Puck failure criterion (PFC).

Thus, this paper aims at developing an GA to pursue the weight optimization of hybrid laminated composite plates using on the PFC. The focus on PCF is because it seems to be a more realistic criterion and it has not been widely explored in optimization problems. The orientation angles were limited to a small set of values, leading the problem to a discrete optimization problem.

To deal with hybrid laminated composites, each individual (design) has two chromosomes: one for materials and the other for ply orientation. Thus, the genetic operators work simultaneously on both chromosomes. As the purpose of the optimization process is to find the minimum weight of the laminate, two operators were developed: one to add and another delete lamina of the laminate.

The constraints of the optimization problem were: first ply failures criterion, maximum number of contiguous plies with the same orientation and buckling load. Also, the plates analyzed are balanced and symmetric. In GA the most common ways of handling

constraints are data structure, repair strategies and penalty functions. The symmetry and balance of the laminate have been handled using the date structure strategy, which consists in coding only half of the laminate and making each stack of the laminate be composed by two laminas of the same orientation with opposite sign. To handle the maximum number of contiguous plies with the same orientation, the Baldwinian repair strategy has been used (Todoroki and Haftka, 1998). A double-multiplicative dynamic penalty approach, which does not need tuning of the parameters, was utilized to introduce the buckling load and failure criteria in the objective function.

A neighboring search after each generation was also implemented in order to obtain a faster convergence. It consists in choosing, among the best designs, two individuals and improving them by testing some modifications on the material as well as the orientation chromosomes.

Several optimization cases were run to validate the proposed model. The results obtained were compared with the ones obtained in the literature.

REFERENCES

[1] R. Le Riche and R. Haftka "Optimization of laminate stacking sequence for buckling load maximization by genetic algorithm", *AIAA JOURNAL*, Vol. **31**, pp. 951-956, (1993).

[2] A. Puck and H. Schürmann "Failure analysis of FRP laminates by means of physically based phenomenological models", *Composites Science and Technology*, Vol. **58,** pp. 1045-1067, (1998).

[3] A. Todoroki and R. Haftka "Stacking sequence optimization by a genetic algorithm with a new recessive gene like repair strategy", *Composites Part B*, Vol. **29,** pp. 277-285, (1998).