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self-adaptative genetic algorithm for minimum thickness composite laminate design

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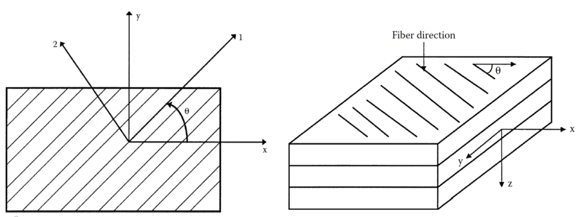

Fig. 1. Lamina

***Abstract*—In this study, a new variant of genetic algorithm(GA) is proposed to minimize thickness of composite laminate subject to in-plane loading. Tsai-wu Failure criteria is used to determinte whether a laminate failures or not.**

***Keywords*—Genetic Algorithm; Composite laminate; Classical laminate theory, Optimal design**

I. INTRODUCTION

This demo file is intended to serve as a "starter file" for IEEE conference papers produced under LaTeX using IEEEtran.cls version 1.7 and later. I wish you the best of success.

mds

January 11, 2007

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II. METHODOLOGY

A. Selection

The purpose of the selection operator is how to chose parents to produce children of better fitness. Traditional methods of selecting strategies only take the fitness of the individual into acount, however, becasue of the existance of constraint, the selection strategies have to change a little bit. The parents of next generation consists of three groups: proper groups, active groups, and potential groups.

Proper parents mean individual fullfils the constraint, which are chosen by the individual's fitnees, individuals with better fitness are more likely to be chosen if they fit the constraint; active groups means that individual is supposed to be always exist in the parents during the GA, which are selected by fitness, ignoring the constraint; potential groups means that they are likely to turn into proper individual after a couple of generations, and potential individuals are chosen by constraint function, the more the individual fulfils the constraint, the more possiblity it will be selected.

B. Crossover

The crossover operator happens among these three groups. the child of two proper groups are more likely to be a proper individual which can be used to obtain a better individual. the child of an anctive individual and a potential individual can significantly change the gene of active individual's chromsome, which lets the individual evolved toward a new direction. The offspring of two active individuals are more likely to be an active individual, which can maitain the active group.

C. Mutation

A mutation direction is imposed on the mutation operator which to make sure the individual evolving toward the right direction. The mutation direction, denoted by md, is a n dimensional vector corresonding to number of constraints, it is decided by the constraint thresholds CT_i and the current individual's constraint value, denoted as CV_i, The mutation vector can be obtained by the following formula

$$\mathrm{md} = [CT_1, \cdots, CT_{n-1}, CT_n] - [CT_0, \cdots, CT_{n-1}, CT_n]$$

During the operator, the mutation consists of two parts, the length of the chromsome, and the angle of the chromsome. Becasue the chromsome's length is positive correlated with the individual's fitness, the coefficient of length mutation denoted by C_l, if $\sum_{i=1}^{N} CT_i$ great than zero, the mutation length is restricted to the range $[0, C_l \sum_{i=1}^{N} CT_i]$; if the $\sum_{i=1}^{N} CT_i$ less than zero, the mutation length is restricted to the range $[0, \sum_{i=1}^{N} CT_i]$; Assuming a $[13_6/-27_4]_s$ carbon T300/5308 composite laminate under the loading $N_{xx} = N_{yy} = 10$ MPa m, the only constraint is the safety factor greater than 1.

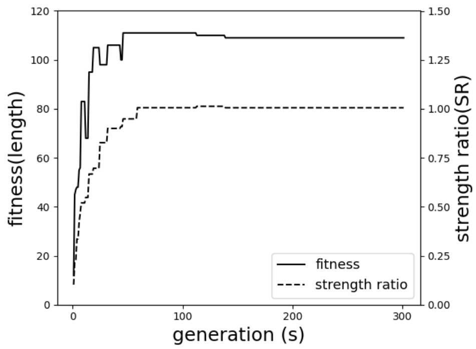

Fig. 2. Two distinct fiber angles

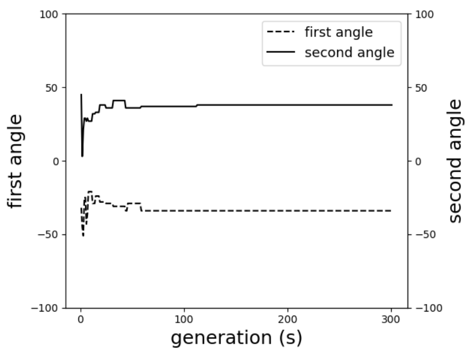

Fig. 3. Simulation Results

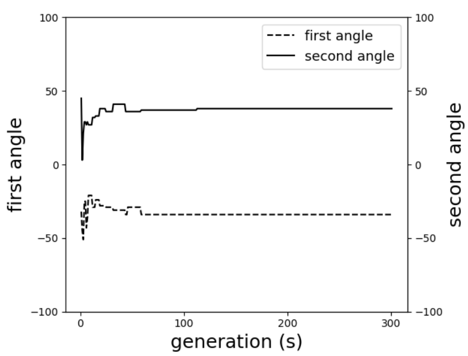

Fig. 4. Simulation Results

Accoring to the Tsai-Wu criterion, its safety factor is 0.0539. So the mutation vector is $[0.941]$, assuming the coefficient is 20, so the mutation range is from 0 to 18. A random number is generated from the range $[0, 18]$, supposing the outcome is 13, then a length generator is used to a list, the it's sum is 13, suppose the list is [5, 8], the laminate after mutation is $[13_{11}/-27_{12}]_s$.

The relationship between the angles in the composite laminate and the chromsome's fitness is unclear, so the mutation direction of chromsome's angle is random. The coefficient angle mutation is C_a, $[0, C_a \sum_{i=1}^{N} CT_i]$

Figure 2 shows how the optimal individual's fitness and strength ratio vary during the GA process, Figure 3 shows how the two distinct fiber orientation changes at the same time, and

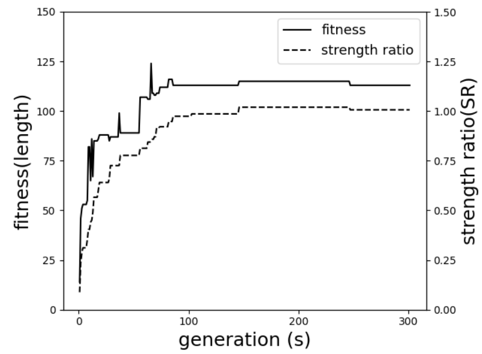

Fig. 5. Three distinct angles

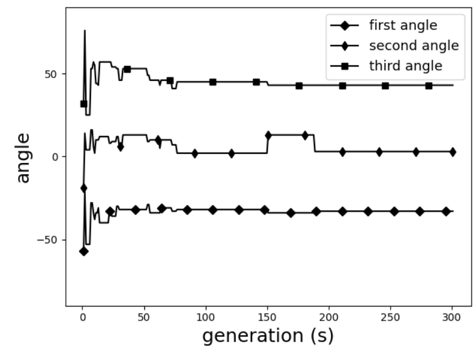

Fig. 6. Results

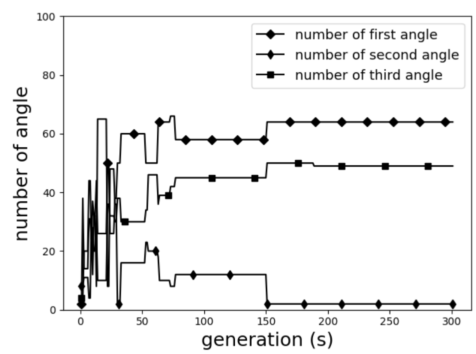

Fig. 7. Simulation Results

TABLE I. AN EXAMPLE OF A TABLE

Property	Symbol	Unit	Graphite/Epoxy
Longitudinal elastic modulus	E_1	GPa	181
Traverse elastic modulus	E_2	GPa	10.3
Major Poisson's ratio	v_{12}		0.28
Shear modulus	G_{12}	GPa	7.17
Ultimate longitudinal tensile strength	$(\sigma_1^T)_{ult}$	MP	1500
Ultimate longitudinal compressive strength	$(\sigma_1^C)_{ult}$	MP	1500
Ultimate transverse tensile strength	$(\sigma_2^T)_{ult}$	MPa	40
Ultimate transverse compressive strength	$(\sigma_2^C)_{ult}$	MPa	246
Ultimate in-plane shear strength	$(\tau_{12})_{ult}$	MPa	68
Density	ρ	g/cm^3	1.590

Figure 4

III. CONCLUSION

The conclusion goes here.

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REFERENCES

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.