MINIMIZATION OF INDUCED STRESS IN MULTILAYERED MEDIUM SUBJECTED TO IMPACT USING PARETO GENETIC ALGORITHM

A. Mohan (MSECE), D. S. Weile, and G. Gazonas (ARL)

University of Delaware • Center for Composite Materials • Department of Electrical and Computer Engineering

Motivation and Objective

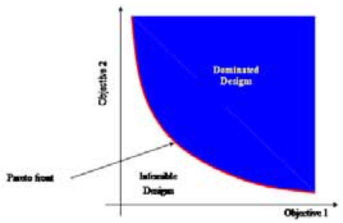
- Optimization of multilayered media for lightweight armor applications is a challenging proposition as many armor grade materials exhibit nonlinear response to transient loading.
- Because of the complexity involved, the optimal design can be obtained by computational means only.
- Pareto Genetic Algorithm will be utilized to minimize the maximum stress in a multilayered elastic-plastic medium

Acknowledgements

This work is supported by the Army Research Laboratory through the Composite Materials Technology program.

Pareto Genetic Algorithm

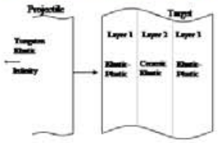
- Pareto Genetic Algorithm is a multiobjective optimization scheme that finds the best possible tradeoffs between conflicting goals.
- The set of Pareto optimal designs is known as the *Pareto front*, and is the object sought by Pareto optimization schemes.



General Approach

- An initial set of chromosomes is generated randomly to give a set of designs.
- The fitness of each design is computed using the objective function.
- The objective function uses Finite Differences in Time Domain (FDTD) to simulate the behavior of a design subjected to an impact.
- On the basis of their fitness values, the chromosomes are processed by the Genetic Algorithm to obtain an optimum design.

Implementation (1)



- The projectile is assumed to stick to the target upon impact.
- The thickness of the projectile has been set to be 100 mils, while the thickness of layer 2 has been fixed at 200 mils.
- The thickness of layers 1 and 3 are varied such that the total thickness of the target-projectile is 1000 mils.

Implementation (2)

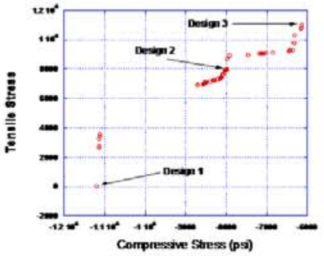
- Mechanical properties of the projectile and layer 2 (elastic materials) are :

	Young's Modulus x 10^6(psi)	Density x10^{-3} (lbf-s^2/in^4)
Projectile	0.9	1.589
Layer 2	53.94	.364

- Mechanical properties of layers 1 & 3 (elastic-plastic materials) are varied between those of Lexan and Tool Steel.

	Young's Modulus x 10^6(psi) (E)	Plastic Young's Modulus (psi)	Density x10^{-3} (lbf-s^2/in^4)	Yield Strength x 10^5 (psi)
Lexan	0.0635	0 to E	0.112	0.11
Tool Steel	5.62	0 to E	0.724	2.2

Results (1)



Pareto Front of Tensile Stress vs. Compressive Stress

Results (2)

- **Design 1**

	Thickness (mils.)	Young's Modulus (psi)	Plastic Young's Modulus (psi)	Density (lbf-s^2/in^4)	Yield Strength (psi)
Layer 1	698	2807500.88	4502.05	2.93e-004	11000.199
Layer 3	2	3226085.51	2574801.60	1.73e-004	108720.29

- **Design 2**

	Thickness (mils.)	Young's Modulus (psi)	Plastic Young's Modulus (psi)	Density (lbf-s^2/in^4)	Yield Strength (psi)
Layer 1	696	63754.356	246.696	1.88e-004	12684.107
Layer 3	4	73743.153	50025.682	4.18e-004	217504.73

- **Design 3**

	Thickness (mils.)	Young's Modulus (psi)	Plastic Young's Modulus (psi)	Density (lbf-s^2/in^4)	Yield Strength (psi)
Layer 1	696	63611.281	219.754	1.50e-004	13017.298
Layer 3	4	104843.55	18924.241	3.73e-004	197812.10