Metal-Polymer Laminate Composite: Modeling and Design, PSED Cluster 2010-2011

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Academic Disciplines:
MECHANICAL ENGINEERING
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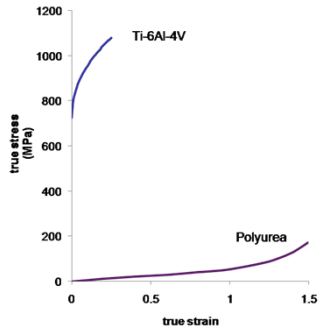
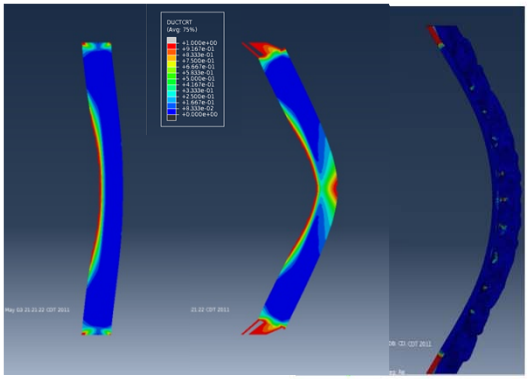
RESEARCH OBJECTIVES

With an increasing risk exposed to terrorist attack, mobile vehicles need improved resistance against blast loading to protect individuals inside. It has been reported that metal-polymer laminate composite (MPLC) may possess improved resistance against ballistic penetration compared to monolithic metallic plate. Our research is to explore if MPLC has superior blast resistance, and to design an optimal MPLC with various configurations.



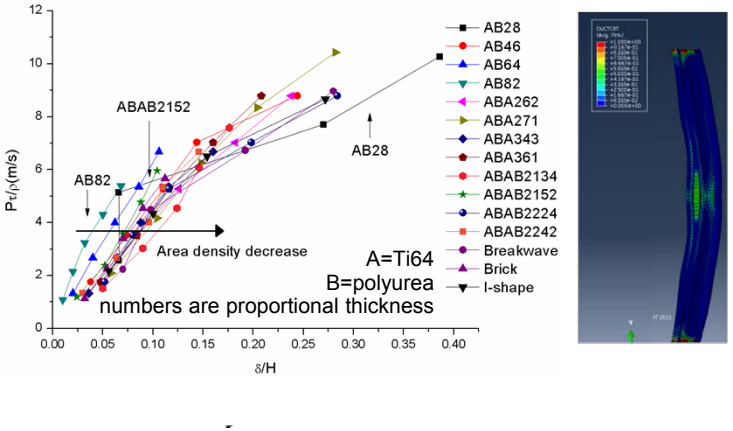
FINITE ELEMENT SIMULATION

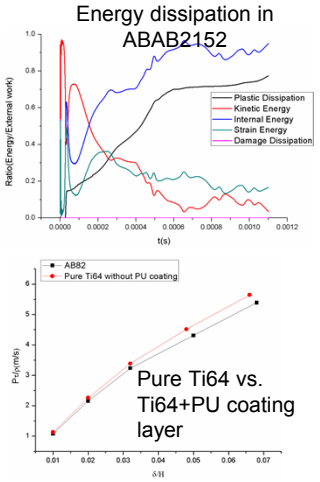
We use a plane-strain 2-D model and spatially parabolic loading decaying exponentially with time. Multiple metal-polymer layers with various thickness ratios were simulated, as well as three special structures. We search for a structure with smallest span-normalized deflection (δ/H) under a certain density-normalized impulse (Pτ/ρ).



MATERIALS DESCRIPTION

Titanium alloys exhibit excellent mechanical performances among light-weight alloys. Polyurea attracts recent research interest for ballistic resistance. We select Ti-64 and polyurea and used their dynamic stress-strain curves (described by Johnson-Cook and Mooney-Rivlin models respectively) reported in literature in finite element simulations. Simple ductile damage criteria are set for both materials.





RESULTS & DISCUSSION

Among all the structures we tested, ABAB2152 which consists of 2 Ti64 and 2 PU laminates gives the best performance. Ti64 itself is a excellent material and pure Ti64 plate is one of the best structures even if it is normalized by its high areal density. However, we do find that ABAB structures, in which PU is constrained by metal laminates and thus experiencing high strain, is the optimal design since PU laminate can absorb more kinetic energy and protect the alloy layer without significant increase in deflection under impact.

It is also found in the simulation that concept design can improve the overall performance to some extent. Obtaining optimized structure with finer mesh, however, is our focus in the future work.

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