

**Research Project:** Nano-enhanced and bio-inspired composite materials for mitigation and protection of TIH railcars and stationary tanks against high power impact

**Research Topic:** Ballistic impact simulation of railcars tanks coated with nano-enhanced composites using hydrodynamic code AUTODYN

**Problem**

Computational simulation is used to analyze ballistic impacts on nano-enhanced composites retrofitted railcars tanks in order to obtain rough guidelines, help the design process, and reduce the number of the firing tests required to achieve the optimal configuration.

**Approach**

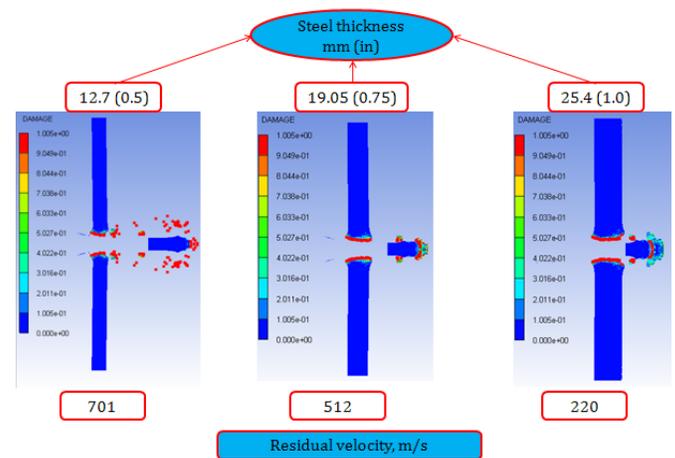
Finite element simulations are conducted using AUTODYN hydrodynamic code in order to study the effect of different factors include steel thickness, coated polymer thickness, layering system, etc...

AUTODYN is commercial computer software for modeling non-linear dynamics of solids, fluids, gas and their interaction. AUTODYN hydrocode is capable of computing strains, stresses, velocities and propagation of shock wave as a function of time and position. Different models, which include Lagrange, Lagrange-Euler coupling, Lagrange-SPH models, are used to evaluate the ballistic impact effect. In the hydrocode simulation, the response of a continuum subjected to dynamic loading is governed by conservation of mass, momentum and energy, and also Equation of State (EOS) and constitutive relation. The EOS takes into account the effect of compressibility of the continuum.

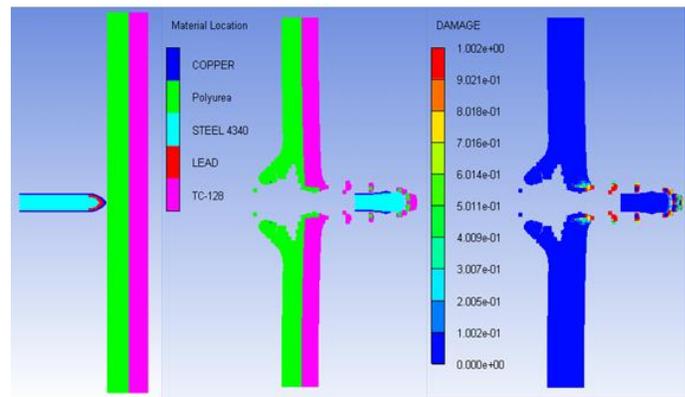
**Findings**

Initial runs are made on ballistic impact loading on railcar tanks steel plate, coated with polyurea, multi-layer system. The following finding may be reported:

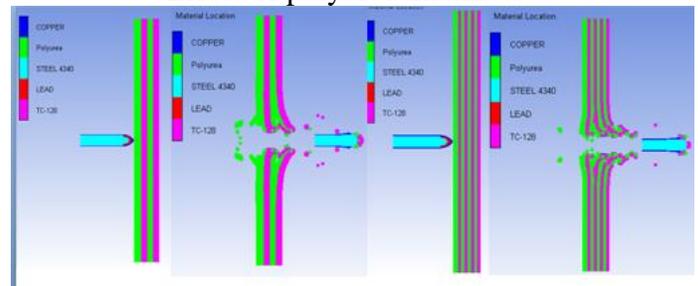
1. The results show that increasing the steel thickness to stop the bullet is not a sufficient solution due to huge additional weight.
2. Using nano-enhanced composites could be a good alternate to protect railcars tanks against ballistic impact.
3. Layering system may be a good choice to dissipate more energy.



Effect of steel thickness



Effect of polyurea thickness



Layering system

**Impact**

Outcome of this research could add rough guidelines, help the design process, and reduce the number of the firing tests required to achieve the optimal configuration.

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