Explosively-Clad, Refractory Barrel Liners for Small Caliber Machine Guns

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Project Objective

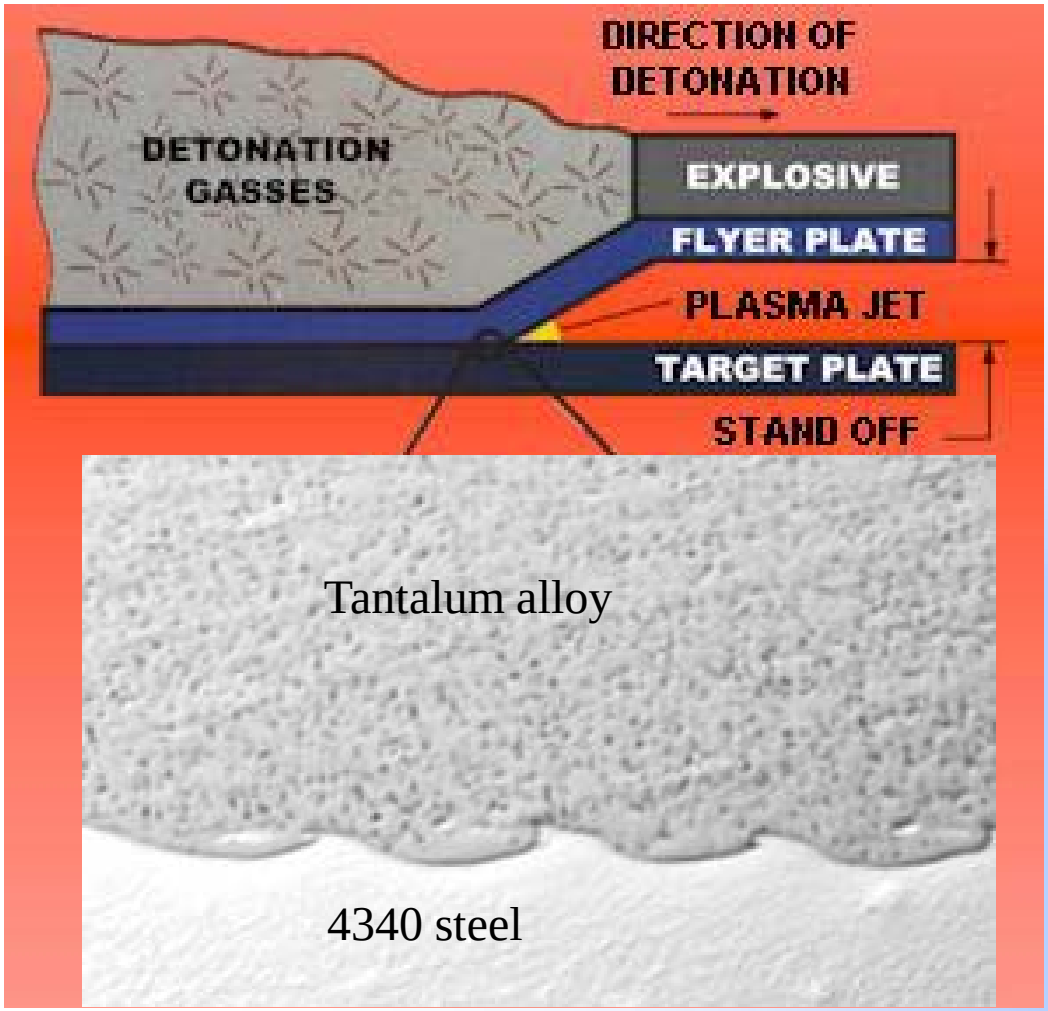
Replace monolithic steel barrels with bi-metallic barrels using explosive bonding

- Increase barrel performance
  - lifespan (number of rounds)
  - increase rates of fire and sustainability
  - increase muzzle energy/range
- Reduce soldier's load/decrease weight

Explosive Bonding

- A solid state joining process that creates a metallurgical bond between dis/similar metals
- High energy impact from a controlled detonation produces atomic-level bonding
- A cold-welding process (no heat affected zone) for similar and dissimilar metals that produces a strong bond and small interface

Explosive Bonding Technology



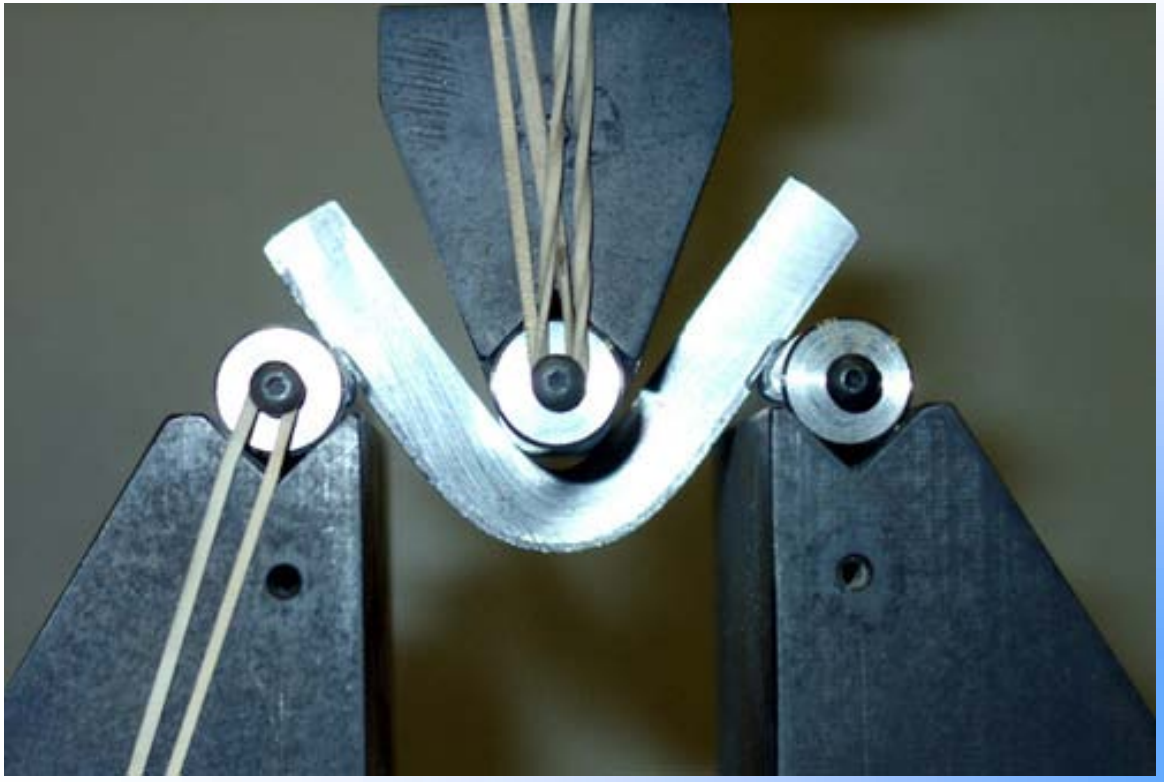
Variables:

- Explosive
  - Type
  - Amount
  - Arrangement
- Impact Velocity
- Impact Angle

Cladding vs. Coating

- Cladding bonds two solid metal parts together
- Coatings are deposited atomically from the liquid or vapor phase (including plasma)
- Solid clad layers do not flake, chip, peel or delaminate like most coatings in the harsh environment of a gun barrel

Interfacial Bond Strength: 3-pt Bend (Ta/steel)



Cladding vs. Coating

- Clad layers can be 0.010-0.120” thick
- CVD and PVD coatings are typically measured in microns
- Chrome coatings are 0.003-0.007” thick
- Clad layers prevent hot gas erosion and subsequent hydrogen embrittlement as well as insulating the barrel material

Clad Gun Barrels

- **A solid-state, bi-metallic tube**

Steel
- Hard
- Strong
- Tough

Tantalum/Stellite
- Refractory
- Tough
- Corrosion-resistant

Tailored barrel mat'l
- Steel: proven
- Inconel: high temp.
- Al, Ti: light weight, corrosion-resistant

TPL-Clad Gun Barrels

5” Navy Gun Breech

45mm test section

Firing Tests

- 25mm Bushmaster w/ XM919 (APFSDS-T) DU rounds (3692K flame temperature)
- Baseline (non-clad) barrel
  - Unserviceable after 229 rounds
  - Destroyed at 375 rounds
- TPL-clad barrel
  - Serviceable after 1385 rounds (no more ammo)
- TPL-clad and rifled barrel
  - Serviceable after 600 rounds (removed)
- 8800 accelerated rounds (~25k rounds) —still serviceable (2010)

Application to Small Arms

- Adapt Barrel Cladding technology to small caliber tubes (5.56mm, 7.62mm, .50 cal)
  - Tailored explosives to reduce critical diameter
- New possibilities with small size
  - Steel barrels will last longer
  - High temperature alloys are possible (*e.g.* Inconel)
  - Low density alloys (*e.g.* aluminum)
- Adapt machining technology, especially rifling

TPL-Clad Gun Barrels

Conclusions

- Refractory lined barrels have demonstrated large increases in longevity
- Explosive bonding is preferred to other methods to line gun barrels (solid metal liner)
- TPL has demonstrated the ability to clad small caliber barrels (Ta/steel M249)
- Potential to eliminate carrying extra MG barrels and changing them in combat
- Results to date indicate longer life, and possibly lighter weight small caliber barrels are possible