OAK RIDGE NATIONAL LABORATORY

FACT SHEET

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Gun Barrel Erosion

Advanced Gun Barrel Coatings

Army Issues and Technology Impact

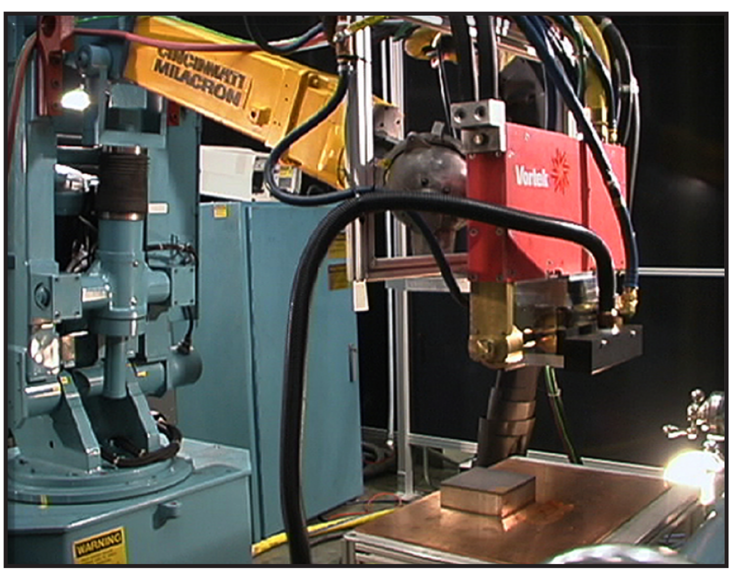
The mechanized weapons systems of the future require affordable, non-eroding coating materials to meet increased performance demands. Advanced propellants produce temperatures and pressures well beyond the capability of current protective gun barrel coatings and can render a barrel unusable within a few rounds.

A new process could be used to apply durable, metallurgically bonded coatings that are impervious to the new propellants, with no damage to the steel of the gun tubes, allowing the use of advanced propellants to engage the enemy at greater distances and with greater effect. Substantially improved gun barrels could be produced for both transformation (FCS/MRAAS) and legacy (M1A1, M113, Crusader, etc.) platforms.

Technical Concept

ORNL’s Infrared Processing Center has developed an innovative approach for the application of refractory metal coatings. High-intensity infrared (IR) energy, produced by the most powerful lamp in the world (300,000 W at 10,000°C), is projected directly onto a refractory-metal, powder-coating precursor to consolidate and form a metallurgically bonded coating on the underlying material. The process has several advantages:

- The plasma-arc lamp focuses the IR energy across a wide area, allowing rapid, cost-effective processing.
- The extremely high rate of heating during the coating process sharply limits the depth of material heating and any associated heat-induced damage in the material being coated.
- The process can produce fully dense, metallurgically bonded coatings of high-melting-point materials on lower-melting-point substrates.



ORNL’s process for metallurgical bonding of high-performance refractory metal coatings uses the world’s most powerful plasma-arc lamp, shown here on a robotic control arm, to project high-intensity infrared energy.

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The leading candidate materials for coating gun barrels are a class of molybdenum-rhenium alloys already being investigated for even more challenging applications as part of the inner wall of nuclear fusion reactors. The ruggedness of this material during gun firing, even with the most advanced propellants, was partially substantiated during recent thermal cycling tests associated with the Crusader Program's advanced gun barrel coating development activities. Existing and advanced chrome- and laser-applied coatings showed extensive cracking after intense thermal cycling (using the ORNL IR plasma source to simulate multiple firings in a gun barrel); in contrast, a rhenium-coated sample showed no deterioration of the coating at all.

Development Approach

A multi-staged approach would demonstrate the feasibility and value of the high-intensity IR application of an advanced refractory metal coating system and minimize the risk of a new technology:

1. development of the optimal refractory metal alloy composition and optimal processing conditions at the laboratory level;
2. tests for resistance to thermal shock and cracking;
3. application of the coating to test sections of gun barrels and evaluation under realistic firing conditions; and
4. transferal of the materials processing technology and equipment to a commercial manufacturing partner for detailed field trials.

We anticipate developing this gun barrel coating system in collaboration with both Benet and Picatinny Arsenals. This approach would proceed in parallel with the development of other coating systems the Army is currently developing (tantalum sputtering and laser-applied coatings).

ORNL Facilities

ORNL's IR-processing facility has two unique features: its Vortek plasma-arc lamps and its PC-based controllers and robotic manipulators for rapid, precise, and reproducible setup and operation. Vortek Industries and ORNL, who are collaborating to develop plasma-lamp-based materials processing technology, are the only two organizations with the 300,000-W arc lamp. This lamp is fully controllable from 2 to 100% of its power and can change power levels in 20 milliseconds. The facility also has a variety of data acquisition and sensing systems including a high-heat-flux sensor that can measure 500,000 W/cm^2, a 3D power profiling system, one- and two-color optical pyrometer temperature measuring systems, a digitally controlled part rotational system, a laser positioning system, environmental control systems, and an on-line video monitoring system.

Related Programs

The proposal to develop IR-consolidated, refractory-metal gun-tube coatings will build upon a wide range of related activities already under way in ORNL's IR-processing laboratory and sponsored by DOE, NASA, BMDO, DARPA, the Army and the Navy, and a number of commercial partners. Even though the use of high-intensity IR energy for materials processing is only a few years old, millions of dollars of research has already been conducted and is continuing on advanced coating systems for wear and corrosion resistance, refurbishment of degraded components, ceramic coatings for fuel cells, fabrication of intermetallic-alloy and refractory-metal sheet directly from powder, and heat-treating of steel and aluminum.

Point of Contact:
Bill Corwin, Manager
Defense Materials Programs
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6161
865-574-4648
corwinwr@ornl.gov

ORNL 2002-01985/jcn