Argonne
NATIONAL LABORATORY

ADDITIVE MANUFACTURING TO ADVANCE MATERIALS DESIGN
APPROACH SHRINKS DEVELOPMENT TIME AND LOWERS COSTS

Argonne National Laboratory can give industry a competitive edge by advancing the use of Additive Manufacturing (AM) for new types of materials and geometries, which allow for the development of products with enhanced properties.

Argonne leverages an interdisciplinary team of material scientists, engineers, computer scientists, and X-ray scientists to capitalize on a unique suite of core lab capabilities:

□ High-performance computing

□ Materials and component characterization and testing, including in harsh conditions and real-operating conditions

□ In-situ observations of AM process and material defects

These core capabilities can be combined with the expertise of Argonne's 1,600 scientists and engineers to tackle AM fabrication of devices in fields as diverse as transportation, defense, nuclear, and aerospace.

BENEFITS

□ Reduced trial and error design

□ Optimized material properties

□ Reduced defects and energy consumption

□ Cost-efficient proof of commercial scalability

UCHICAGO ARGONNELLC

U.S. DEPARTMENT OF ENERGY

Additive Manufactured Engine Head for Improved Combined Heat and Power Performance

Scientific Advance: Using AM to make complex geometries of engine components (cooling passages, ports, igniter locations, etc.) and with materials that will withstand high pressures and temperatures without a loss of mechanical properties.

Argonne Difference: Oak Ridge National Laboratory generated a 3-D model of the engine head from Argonne's Single Cylinder Research Engine and evaluated high-strength bimetallic samples. The prototype was tested at Argonne using porotype igniters to explore enhanced engine combustion technologies.

Impacts: ANL's engine research team worked with ORNL's materials research team to demonstrate the commercial viability of using AM for manufacturing custom engine parts to improve engine efficiency. The first iteration of the 3-D printed head match closely with the stock head. Performance testing is on-going.
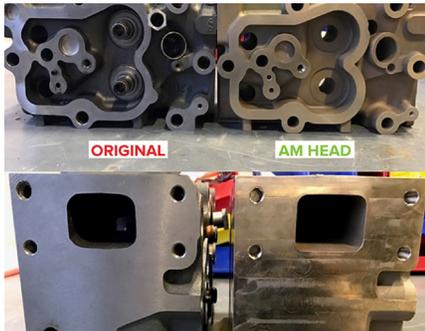
High-fidelity simulations reveal the temperature distribution inside metal component of an engine piston bowl that will be optimized to reduce heat transfer losses and improve engine performance.

High-Performance Computing to Improve AM Engine Design

Scientific advance: The use of high-fidelity simulations can lead to novel engine designs to increase fuel efficiency and reduce emissions in diesel engines for heavy-duty vehicles. Argonne and Caterpillar are partnering to create a new engine design that will be based on simulations of piston and fuel spray geometry, which take into account the more complex geometries made possible by the AM process.

Argonne Difference: Argonne's experts in fuel spray and combustion modeling are using high performance computing at the Mira supercomputer to create high-fidelity simulations of a novel piston bowl and fuel injection designs. These state-of-the-art designs will be used by Caterpillar to AM the engine component.

Argonne demonstrated that complex surface irregularities that may be generated due to AM of engine parts can significantly affect spray structure from fuel injector.

Impacts: This work will create a more efficient diesel engine, reduce manufacturing design and lead time, and generate a proof-of principal design that could accelerate the adoption of AM for high-volume engine component production.

AM-Printed Microchannel Plates with Increased Performance

Scientific advance: AM-printed plates provide higher spatial resolution at 1 mm pores, and 10 times higher gain and counting rates at 100 to 1,000 times cheaper production. The improved resolution can improve detection by 50 percent.

Argonne Difference: Argonne developed a novel AM printing technique based on two-photon polymerization stereolithograpy that enables the printing and activation of detector structures with properties that dramatically exceed the state-of-the-art competitor detectors. Argonne has decades of leadership in microchannel plate design and AM work involving Atomic Layer Deposition.

Impacts: This enables the printing crucial components of military night vision googles at a fraction of the cost, increased resolution and lighter weight. This makes it financially viable for U.S. companies to start manufacturing the googles to decreases a reliance on foreign goods. This also enables the building of advanced detectors for high-energy physics research, defense and homeland security applications and medical imaging.

3D printing of microchannel plates such as above with 300 nm walls, enables improved performance at a fraction of the cost. Such plates are key components of advanced performance detectors such as those used in night vision goggles.

TECHNICAL CONTACTS

Doug Longman
Section Manager,
Engine Combustion Research
Energy Systems Division
Argonne National Laboratory
Phone: 630-252-4257
Email: dlongman@anl.gov

Sibendu Som
Manager
Computational Multi-physics Section
Argonne National Laboratory
Phone: 630-252-5273
Email: ssom@anl.gov

Michael Pellin
Argonne Distinguished Fellow
Materials Science Division
Argonne National Laboratory
Phone: 630-252-3510
Email: pellin@anl.gov