

# INDUSTRIAL TECHNOLOGIES PROGRAM

## The Development of Surface Engineered Coating Systems for Aluminum Pressure Die Casting Dies: Toward a “Smart” Die Coating

Aluminum pressure die-casting dies degrade and fail by three mechanisms: (1) soldering; (2) wear/erosion; (3) thermal fatigue. Researchers in the Advanced Coatings and Surface Engineering Laboratory (ACSEL) at the Colorado School of Mines (CSM) showed in their past research that die life can be extended by as much as four times using appropriate coatings and surface modification. Such an extension of die life will translate into energy savings of melting and machining of the die steel alone of approx.  $54 \times 10^6$  BTUs/tons die steel as well as the energy consumed in the die tool steel used, the repair and maintenance of the dies, and the decreased downtime of the dies.

Colorado School of Mines has developed a design methodology that differs from the existing trial-and-error approach for die casting

selection. CSM researchers have identified a range of optimized coating architectures that can be used in aluminum pressure die-casting. They are using a combination of finite element modeling (FEM) coupled to laboratory experiment and in-plant trials to develop a series of optimized coating architectures and designs of overall coating systems. These optimized coating systems will be extended into the development of a ‘smart’ die coating that will indicate the state and condition of the die and provide input as to when a die should be removed prior to catastrophic degradation and wear.

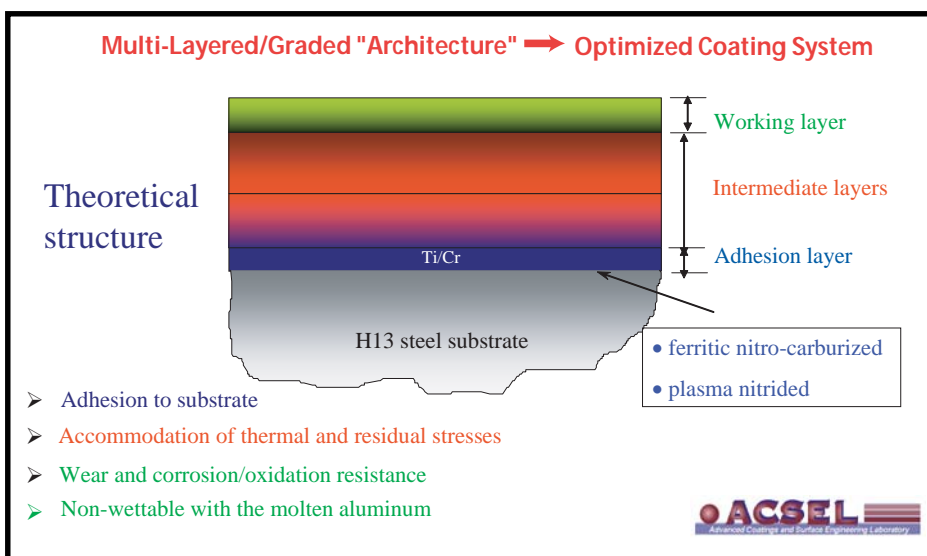


### Benefits for Our Industry and Our Nation

- *Extended die life by four times (400%)*
- *Decrease downtime due to maintenance or repair*
- *Reduced energy consumption in die making*

### Applications in Our Nation's Industry

*This tool will extend the die life for die casters and reduce their overall die replacement cost. The development of a ‘Smart Die’ will assist all die casters in knowing when to change a die before the die fails and optimize the die casters productivity.*



## Project Description

This research program will be conducted in two complementary areas (themes). The primary theme will be to develop a range of engineered coating systems that will substantially extend the life and performance of dies used in aluminum pressure die-casting. The second theme will be to develop a 'smart' die coating system based on incorporating a matrix of piezoelectric thin film sensors within an optimized coating system. The 'smart' die coating system will enable monitoring the strains generated in the die, and indicate the initiation of micro-cracking and crack propagation in die components or die coatings. The technology transfer will occur through the participation of the industry partners on this research program.

## Milestones

### Results to Date

1. Performed optimization of the ACSEL-developed coating system and conducted multi-mode and in-plant testing of optimized ACSEL and commercial coatings

### Future Milestones

1. Characterization and evaluation of degradation mechanisms
2. Design and optimization of piezoelectric films
3. Produce a series of prototype 'smart' coatings
4. Evaluation of 'smart' coatings using a robotic multi-mode tester
5. Characterization and evaluation of degradation mechanisms of 'smart' coatings

## Project Partners

*Colorado School of Mining*  
Golden, CO  
*North American Die Casting Association*, Wheeling, IL  
*Cast Metals Coalition Partnership*  
Charleston, SC  
*Badger Metals*, Appleton, WI  
*Balzers Inc. (USA)*, Elgin, IL  
*Briggs and Stratton*, Milwaukee, WI  
*GM Powertrain*, Bedford IN  
*Hayes-Lemmerz*, Northville, MI  
*Ion Bond*, Madison Heights, MI  
*Leggett and Platt*, Carthage, MO  
*Phygen*, Minneapolis, MN  
*Premier Tool and Die Cast*  
Berrien Springs, MI  
*St. Clair Die Casting*, St. Clair, MO  
*Teer Coatings*  
Worcestershire, U.K

## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.



U.S. Department of Energy  
**Energy Efficiency  
and Renewable Energy**  
Bringing you a prosperous future where energy  
is clean, abundant, reliable, and affordable

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