I/UCRC Executive Summary - Project Synopsis	**Date**: April 2020

Center/Site: CANFSA/Colorado School of Mines

Tracking No.: Project 37: Advanced Engineered Coatings with Extended Die Life for Tooling	**Phone:** (720) 774-1233	**E-mail:** ndelfino@mymail.mines.edu

Center/Site Director: M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Nelson Delfino de Campos Neto/Stephen Midson/Andras Korenyi-Both/Michael Kaufman	**Proposed Budget**: $455,000, Leveraged

Project Description: PVD coatings applied to steel die casting dies help prevent the aluminum from soldering to them, allowing a reduction, or even elimination, of the lubricants applied to the die prior to each shot. Elimination of lubricants can significantly improve the quality of the die castings, allowing them to be used in new, higher performance applications. In addition, production costs can be decreased, resulting in lower per-part costs, as well as die life being significantly extended. Advanced PVD coatings will be identified and laboratory tested to determine the best coating working layer and architecture (single or multi-layer) to avoid both adhesion of molten Al and thermal fatigue during aluminum die casting. In addition, the mechanisms controlling the adhesion of molten aluminum to the die faces will be evaluated.

Experimental plan: An enhanced laboratory test has been developed to test the level of adhesion between molten aluminum die casting alloys and a range of coatings. Various coatings and coating architectures will be examined to determine those working layers (top layers) that exhibit no reaction, and ideally no wetting, against the molten aluminum alloy. In addition, the impact of coating architecture on coating durability will be evaluated. The optimum coating architecture and working layer will be evaluated in die casting plant trials.

Related work elsewhere: Bo Wang, "An Investigation of the Adhesion Behavior of Aluminum on Various PVD Coatings Applied to H13 Tool Steel to Minimize or Eliminate Lubrication During High Pressure Die Casting", PhD thesis, CSM, 2016.

How this project is different: The previous project performed by Wang was able to reduce lubrication by 85% - the objective of this work is to totally eliminate the need for conventional lubrication. To achieve this, the mechanisms controlling adhesion of molten aluminum to dies will be identified and addressed.

Milestones for the current proposed year: Perform tests using the improved aluminum adhesion test. A list of coatings to be tested has been developed, but additional coatings will also be evaluated. Experiments will be performed to determine mechanisms related to the adhesion of molten aluminum to coatings and substrates.

Deliverables for the current proposed year: (1) Literature review; (2) Tests using the improved aluminum adhesion test apparatus; (3) Results from tests on the PVD coated samples (4) Characterization of interfaces.

How the project may be transformative and/or benefit society: This project can lead to a significant improvement in the quality of die castings, allowing them to be used in higher performance applications, which is significant as die casting is normally the lowest cost approach to produce complex aluminum shapes. In addition, production costs can be further reduced, resulting in lower per-part costs.

Research areas of expertise needed for project success: Metallurgical and mechanical engineering, PVD coatings, die casting, die manufacture, laboratorial testing and characterization, microscopy.

Potential Member Company Benefits: Die casting is typically the lowest cost approach for making complex-shaped aluminum components. By increasing the quality of die castings and reducing their cost, the improved castings can meet the requirements of member needs.

Progress to Date: Literature review has been performed to: (1) develop an improved adhesion test; (2) identify mechanisms involved in adhesion; and (3) identify the best PVD coatings and coating architectures. An improved aluminum adhesion test has been developed and some tests have been performed. Further tests are proposed on a number of PVD coated samples that have been obtained.

Estimated Start Date: Fall 2018	**Estimated Knowledge Transfer Date**: Spring 2023