I/UCRC Executive Summary - Project Synopsis	**Date**: March 2019

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: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type:** Continuing
Project Leaders: Nelson Delfino de Campos Neto / Stephen Midson / Andras Korenyi-Both / Michael Kaufman	**Proposed Budget**: $455,000

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 will be developed to test the level of adhesion between molten aluminum die casting alloys and a range of coatings. This test can include pressurization/fast filling of the molten aluminum against the substrate to ensure that the industrial die casting process is well simulated. 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. In addition, the mechanism controlling adhesion behavior of molten aluminum to dies will be identified and addressed.

Milestones for the current proposed year: Performed trials using an improved aluminum adhesion test. Further improvement will be made to this test to better simulate the die casting process, and if needed, it will incorporate a system to pressurize and/or provide a high velocity of the liquid aluminum against a coated substrate. A variety of PVD coatings will be tested. 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 and further improvements in the aluminum adhesion tester; (3) Results from initial testing using bare, polished H13 steel and PVD coated samples.

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: As noted above, die casting is typically the lowest cost approach for making complex-shaped aluminum components. By increasing the quality of die castings, the castings can meet the requirements of member's needs.

Progress to Date: Literature review has been performed to: (1) Develop an improved adhesion test; (2) Identify mechanisms involved in adhesion; (3) Identify the best PVD coatings and coating architectures. An improved aluminum adhesion test has been developed and initial testsing performed to prove the concept.

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