I/UCRC Executive Summary - Project Synopsis	**Date**: April 2022
Center/Site: CANFSA/Colorado School of Mines	
Tracking No.: 54: Lubricious PVD coating for forging dies	**E-mail:** jvazquez@mines.edu **Phone:** (720) 768-5180
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Jesus Vazquez	**Proposed Budget**: $320,000
Project Description: The objective of this project is to reduce or eliminate the need for conventional lubricants during the forging process through modification of the die surface by applying permanent thin-film lubricious coatings applied to the faces of the forging die or using surface texturing.	
Experimental plan: Use the ring forging test to obtain quantitative values for friction of the coated dies using an Al 6061 ring with and OD:ID:height ratio of 6:3:2 to understand the mechanism(s) under which some coatings or surface textures reduce friction during forging.	
Related work elsewhere: This research leverages the knowledge base developed during recent related coating research performed at the Colorado School of Mines, which includes successful projects to minimize conventional lubricants for die casting, and an exploratory project funded by the Foundry Industry Educational and Research Foundation (FIERF) to examine coatings for forging dies that showed certain coatings have the capability to considerably reduce friction between the die and workpiece, and potentially dramatically reduce the amount of conventional lubrication required.	
How this project is different: Most studies of forging die coatings have concentrated on the reduction of wear to improve die lifetime, this project focuses on the reduction of friction coefficient to reduce or eliminate the use of lubricants which may also bring a lifetime extension to the dies.	
Milestones for the current proposed year: Initiate testing of diamond-like-carbon (DLC), vanadium containing and i-Kote variation coatings; continue the characterization of the previous coatings tested at room temperature; start high temperature testing and prepare the die holders for the 1800 kN (400-kip) tests.	
Deliverables for the current proposed year: Develop and understanding of the desired properties for an ideal coating and the mechanisms that reduce friction during forging. Continue the literature review to determine which type of coatings and/or surface modification techniques show promise to reduce the coefficient of friction in forging dies.	
How the project may be transformative and/or benefit society: By modifying the surface of forging dies with permanent coatings and/or texturing, there is an opportunity to significantly reduce or eliminate the amount of traditional die lubricant that is sprayed during the conventional forging process, resulting in cycle time reductions and material savings. In addition, such surface modifications have the potential to increase die life by reducing wear and the thermal fatigue that results from spraying lubricant on a hot die. Both the cycle time reduction and longer die life will result in lower part costs. In addition to cost savings, these surface modifications could increase part quality, improve productivity, and reduce environmental hazards.	
Research areas of expertise needed for project success: Access to different types of commercially available lubricious coatings, test equipment that simulates forging parameters, ability to characterize the coatings that have the best performance to understand the friction reduction mechanism(s) that they provide.	
Potential Member Company Benefits: Lower friction translates to lower forging forces, shorter cycle times, longer die lifetimes, and lower part costs. The elimination of lubricants has environmental benefits.	
Progress to Date: Established the baseline for the friction factor of uncoated dies with different surface roughness tested on room temperature nitride, zirconium oxide, BN based coatings, and i-Kote. Initiated characterization using SEM/EDS, profilometry, XRD and optical microscopy of the coatings.	
Estimated Start Date: Spring 2021	**Estimated Knowledge Transfer Date**: December 2024