Wear-resistant Surface Technologies for Low-leakage NG Compressors

Agreement Number: 30174
Argonne National Laboratory
Project Period: 10/01/2015-09/30/2019

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U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 11-12, 2019

Overview

AMO MYPP Topic

- Materials for Harsh Service Conditions

Timeline

- Award issued: FY2016
- Projected End date: September 2019
- Project 90% complete

Budget

	FY 16 Costs	FY 17 Costs	FY 18 Costs	FY19 Costs	Total
DOE Funded	$700K	$700K	$436K	$264K	$2.1M
Project Cost Share	-	-		$235K	$235K

Barriers

- Methane leakage through the sealing surfaces of natural gas compressors is a major problem.
- Traditional seal materials are unable to provide long wear life and require frequent replacement which increases cost.

Partner

- Dover Precision
  - Major seal manufacturer in U.S.
  - Key support in seal material development and rig testing.

Project Objective

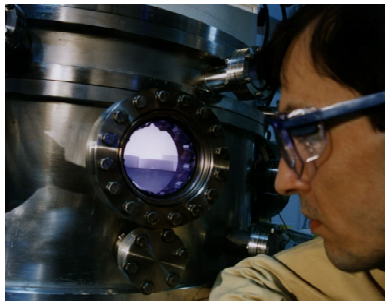
- Current compressor technology is more than 50 years old and methane leakage is a major problem
  - Traditional seal materials are unable to provide long wear life and to maintain tighter sealing
  - Further, estimates suggest that these compressors consume huge amounts of energy (i.e., 2 quads in 2012 or about 2 percent of total U.S. energy use*)
- **Objective:** To develop and implement self-lubricating, high-wear resistant seal materials, coatings, and surface treatments on sealing surfaces to mitigate natural gas leakage from the reciprocating compressor systems.

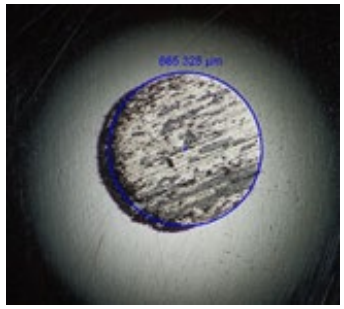
* Data provided by the Energy Information Administration (EIA) indicate that the annual amount of natural gas used to transport natural gas through the pipeline system was about 0.7 quadrillion Btu. In addition to the pipeline natural gas use, compressors are used in the gathering and processing of natural gas, which is accounted for in the 1.4 quadrillion Btu of natural gas reported by EIA as “lease and plant fuel”.

Technical Innovation

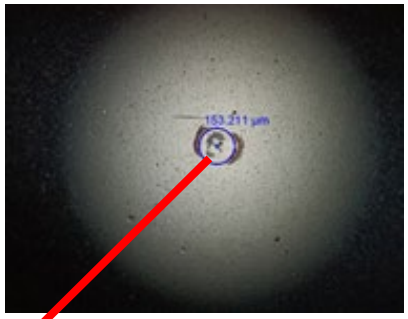
- **Near Frictionless Carbon (NFC)**: A form of amorphous hydrogenated diamondlike carbon (DLC) coating with friction coefficients below 0.01. Thickness : 1-10 µm

- **Catalytically Active Nano Composite (NC) Coatings**: A new revolutionary coating technology that extracts DLC tribofilms from methane, in situ, and on demand to dramatically reduce wear.

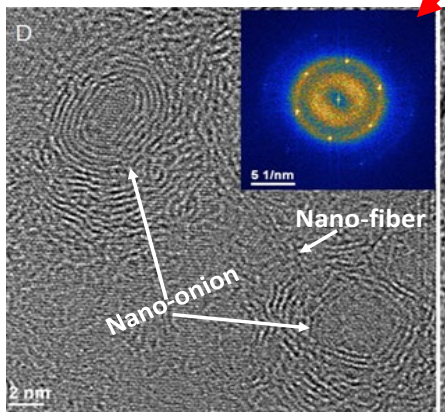


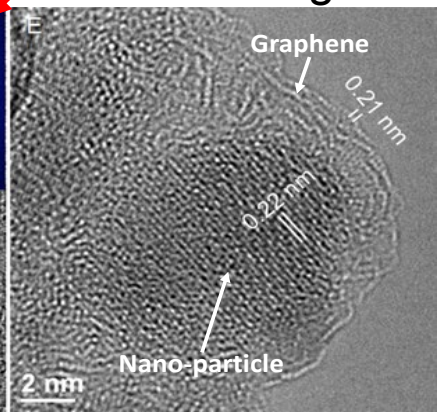


No coating



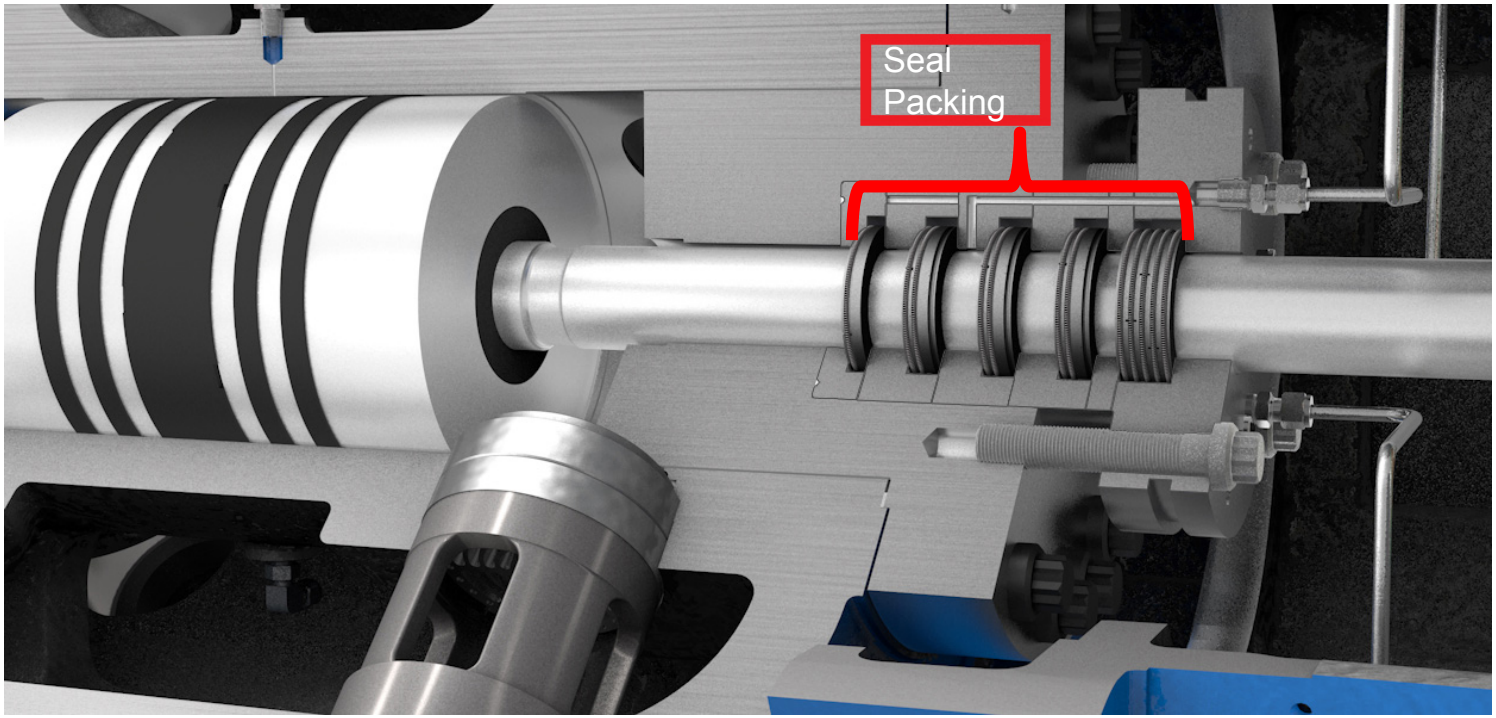
NC-coating





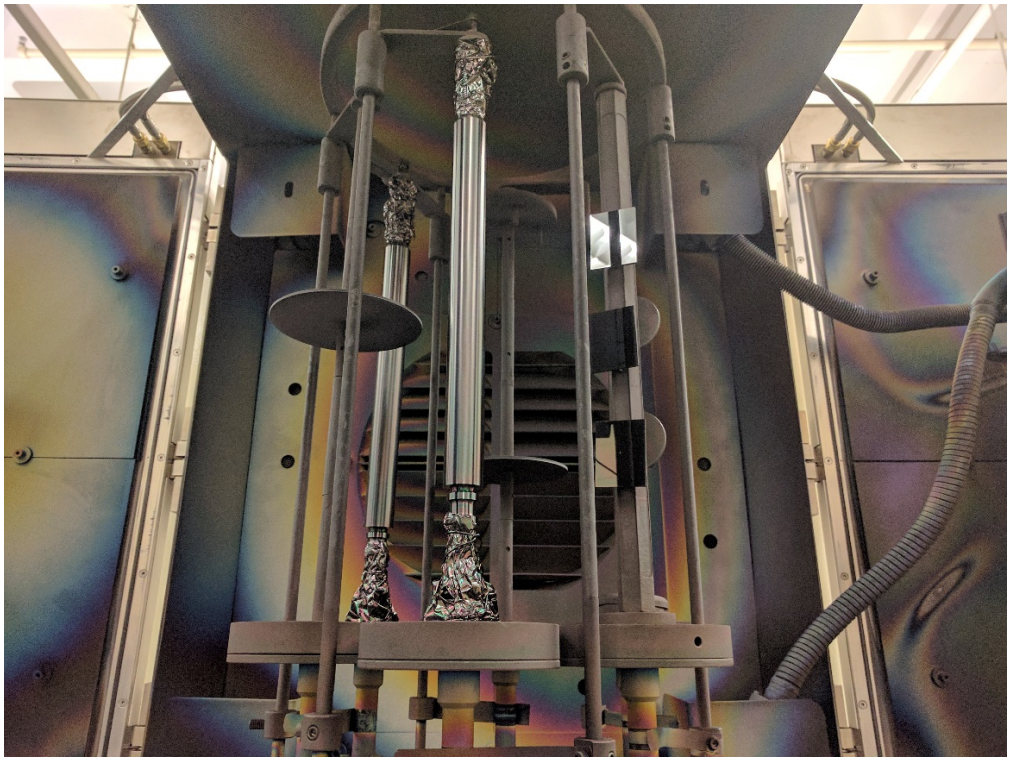
Technical Innovation

- **Synthesis of New Seal Compositions for NG Compressors**
  - Fine tuning the composition by adding NG compatible solid lubricant powders that can create NG compatible tribo-films, which in turn can result in lower coefficient of friction and longer wear life.



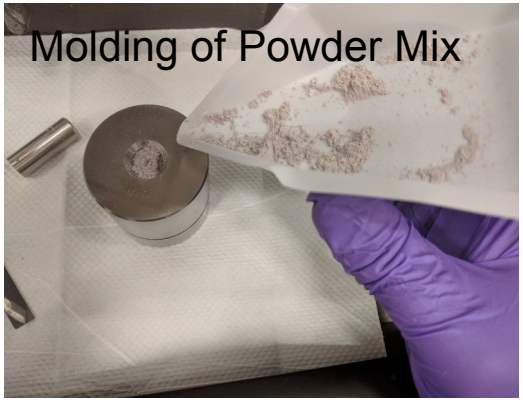
Technical Approach

- **TASK: Assessment of long term friction/wear performance of down-selected seal-coating couples for NG compressors**
  - Long-term testing of selected test pairs (coatings and seals)
  - Coating of compressor components
  - Component level testing

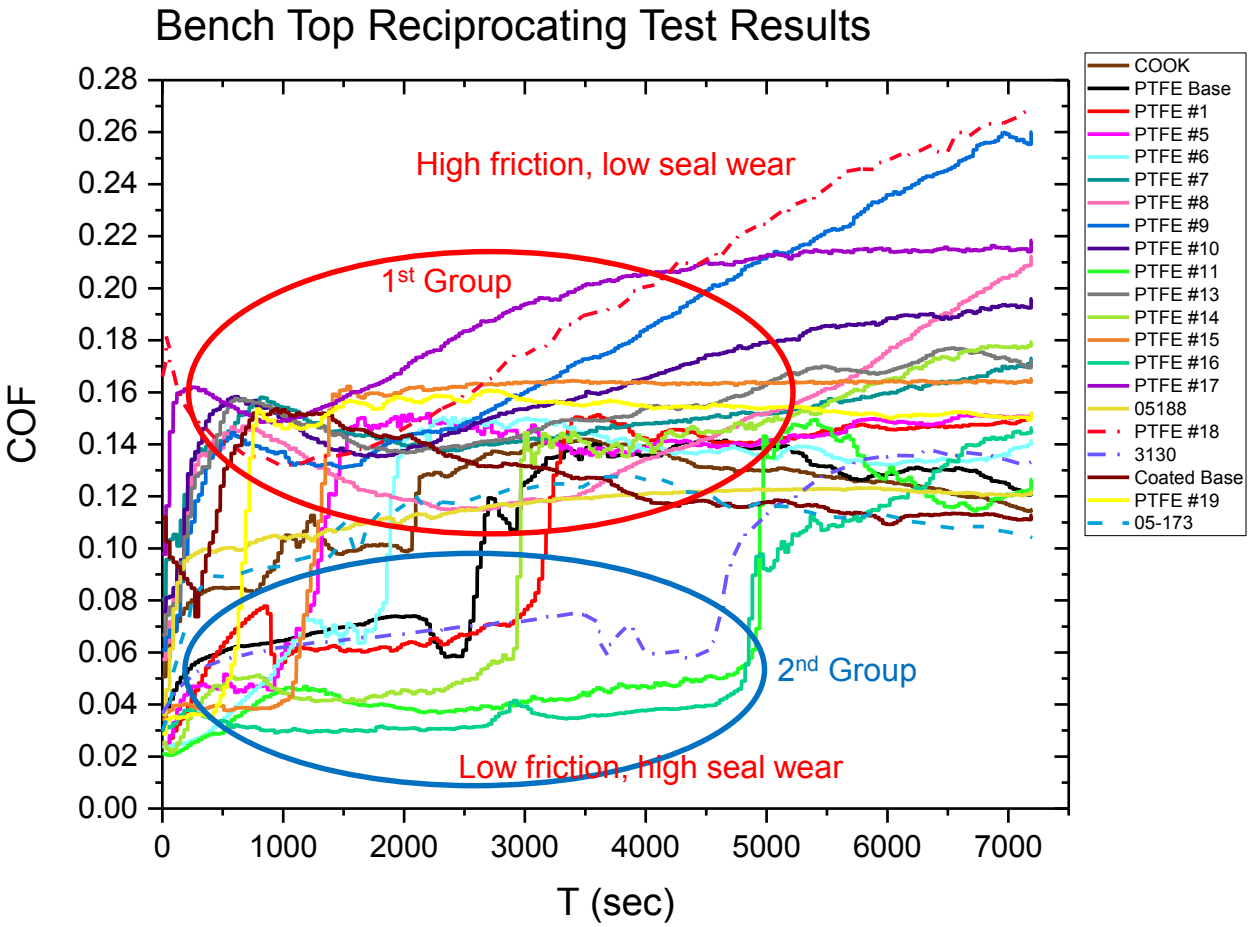


Technical Approach

- **TASK: New Seal Materials Synthesis, Fabrication, and Testing**
  - Create new seal compositions based on PTFE with ANL fillers
    - 2 new metal-based solid lubricant fillers
    - 2 new compound-based solid lubricant fillers
  - Manufacture bench top test coupons (10-20 different combinations) and perform benchtop tests.



Results and Accomplishments



Seal Synthesis - Compositions

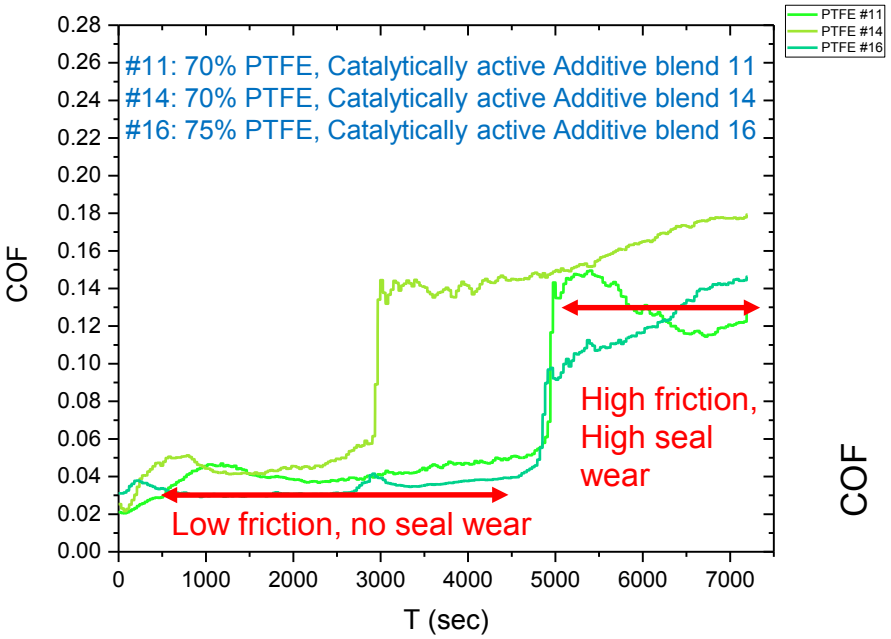
Sample Name	PTFE	Carbon	Copper	Graphite	Ni (93-2867)	Ni (93-2880)
PTFE #1	75	11.5	11.5	2		
PTFE #2	75	11.5		2		11.5
PTFE #3	75	11.5		2	11.5	
PTFE #4	75		23	2		
PTFE #5	75			2		23
PTFE #6	75			2	23	
PTFE #7	50	25	25			
PTFE #8	50	25				25
PTFE #9	50	25			25	
PTFE #10	50	25	12.5		12.5	
PTFE #11	70		15		15	
PTFE #12	75	23		2		
PTFE #13	50	25	12.5			12.5
PTFE #14	70		15			15
PTFE #15	75	11.5		2		
PTFE #16						
PTFE #17	50	25				
PTFE #18	50	25				
PTFE #19	75	11.5		2		
PTFE #20	75			2		
PTFE #21	50		25		25	
PTFE #22	50		24	2	24	
PTFE #23	48	25		2	25	
PTFE #24	50				25	
PTFE #25	70	25	3	2		

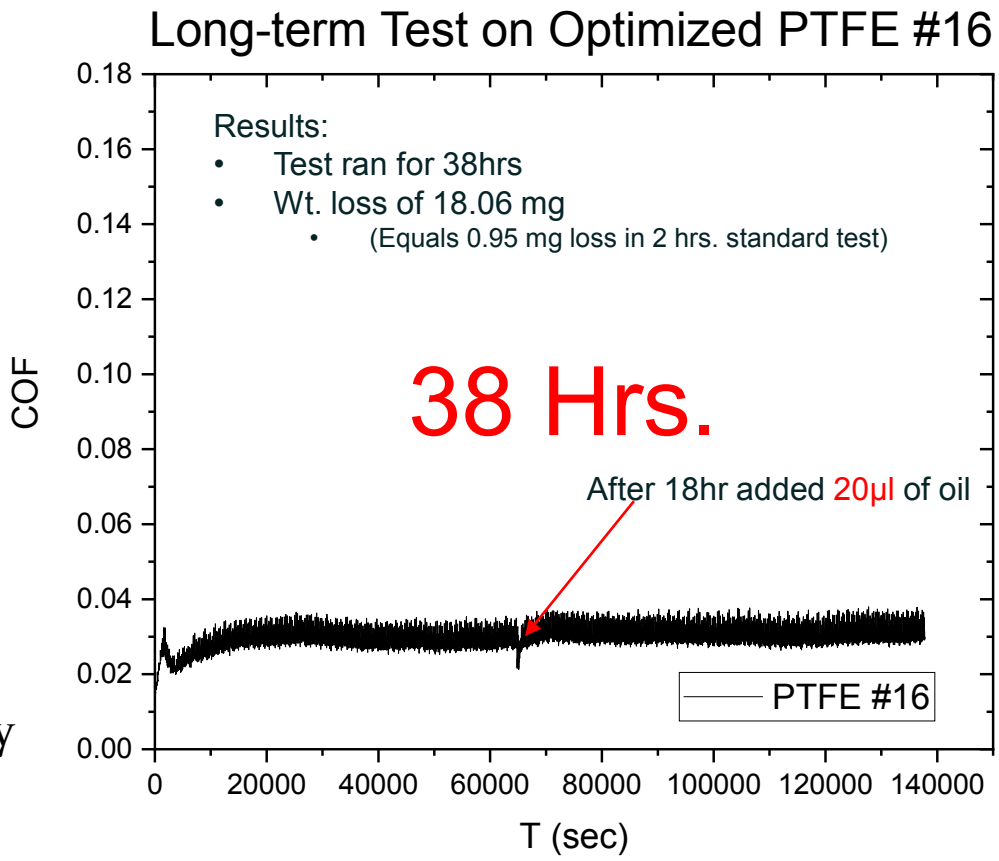
Sample Name	PTFE	Carbon	Copper	Graphite	Ni (93-2867)	Ni (93-2880)
PTFE#2616C	65	5		2		
PTFE #2716PC	65	5		2		
PTFE #28	65	5	11		19	
PTFE #29	65	5	11			19
PTFE #3016P	65			2		
PTFE A	86			4		
PTFE B	75			5		
PTFE C	75			10		
PTFE #31	75	23				
Base G1	75	23		2		
Base G2	75	23		2		
PTFE #32	75			2		
PTFE #33	75			2		
PTFE #34	75	2				
PTFE #35	75			2		
PTFE #36	75			2		

- Key observation from bench-top tests:
  - High friction, low seal wear group
  - Low friction, high seal wear group

Results and Accomplishments

Screening test results on down selected Seal Compositions





- Seal wear was reduced by factors of 6 (from 6 mg to less than 1 mg)
- Coefficient of friction was reduced by factors of 3 (from 0.12 to 0.04) times compared to baseline seal.
- Rig tests are underway to confirm bench-top results

Transition (Beyond DOE Assistance)

- **Who Cares?** US Government Agencies and industrial stakeholders involved in the production, delivery, storage, and use of natural gas.
- **Who is the end user?** Natural gas compressor manufacturers and pipeline operators.
- **How will they use it?** They will procure new seals developed under this program from the current seal manufacturer/CRADA partner.
- **Does it improve their mission/capabilities?** Yes, it will lead to higher durability/reliability (hence, lower maintenance cost) and reduced methane leakage.
- **What is the commercialization approach?** Joint development, scale-up and deployment through CRADA with our industrial partner. This will be followed by intellectual property licensing by the partner company beyond FY19 timeframe.
- **What is the technology sustainment model?** Marked improvement of seal life/performance using transformational surface technologies. Mitigation of methane emission at its source.