

Erosion / Corrosion Resistant Coating Evaluation for MH-47's T55 Compressor Airfoils



COATING TECHNOLOGIES CORPORATION

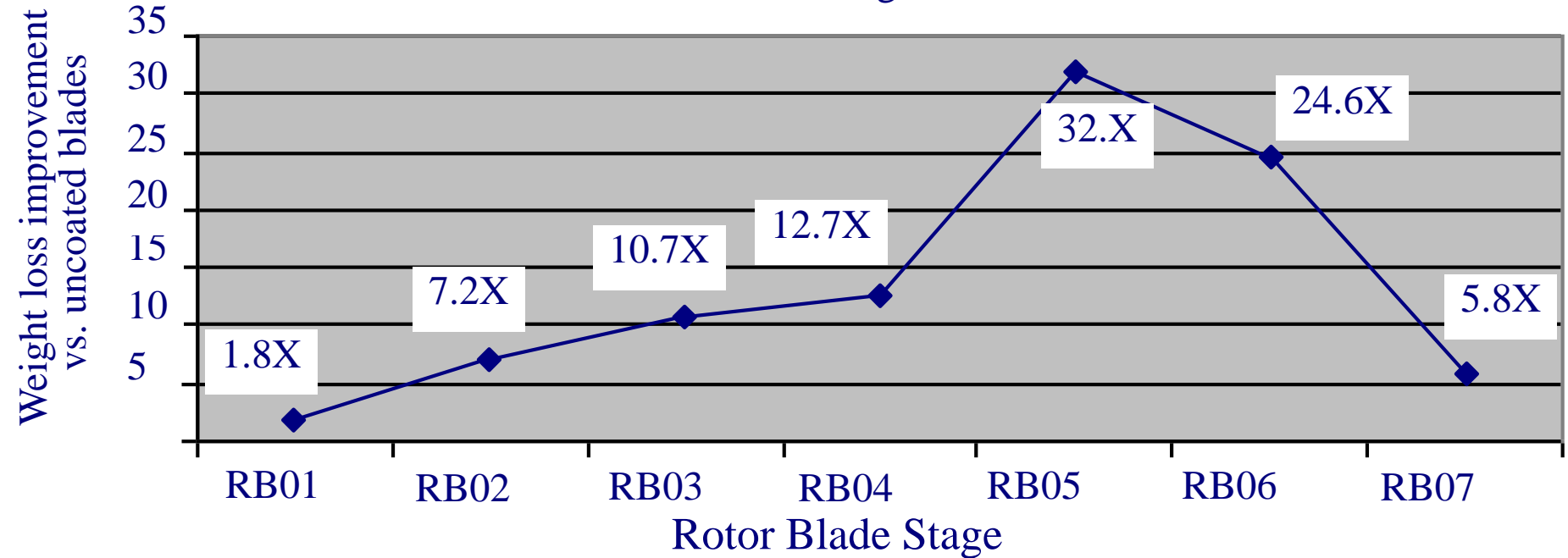


U.S. Army Coating Evaluation Program Summary

- 7 coating vendors + uncoated blades evaluated in 2007-08 U.S. Army CIP program
- Engine sand ingestion test in “rainbow” configuration completed in Dec 2008
 - MCT’s Erosion Resistant coating demonstrated “significant improvement in erosion resistance over uncoated blades” and rated best against erosion
- Program cancelled in August 2008 due to corrosion concerns
- MCT continued efforts to develop robust erosion / corrosion resistant coating
 - Results presented to Boeing / Honeywell and U.S. Army in August 2010
- Honeywell issued test report that concluded enhanced corrosion resistant coating acceptable for both erosion and corrosion

T55 Engine Sand Ingestion Test

C-Spec Media
MCT Erosion Resistant Coating vs. Uncoated Blades



- Total sand ingested = 25.4 lbm of C-spec sand
- Total test time ~ 6 hour test
- Ingestion rate = 4.3 lbm / hour

Boeing / SOAR Program Plan

- U.S. Army's Special Operations Aviation Regiment (SOAR), identified operational need to increase engine time-on-wing due to compressor airfoil erosion
- Boeing contributed funds via Industrial Regional Benefits programs to continue evaluating MCT's BlackGold® erosion / corrosion resistant coating.
 - Original work scope
 - Conduct corrosion tests on uncoated and MCT coated blades
 - Conduct component level erosion tests
 - Conduct fatigue tests
 - Conduct sand ingestion test on uncoated and coated engine at HWL
 - Install coating on SOAR lead-the-fleet Chinooks

Corrosion Test

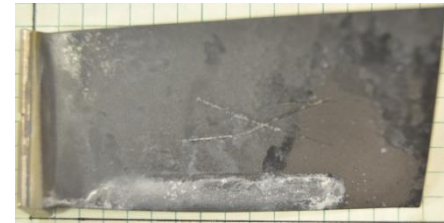
- AED approved corrosion test plan conducted July 2013 by University of Alabama at Huntsville
 - Conduct corrosion test on six (6) uncoated and six (6) coated 1st stage compressor blades
 - Conduct test per ASTM B117 test standard over 17 days
- BlackGold® coated blades met test objective and provided greater corrosion protection than uncoated blades



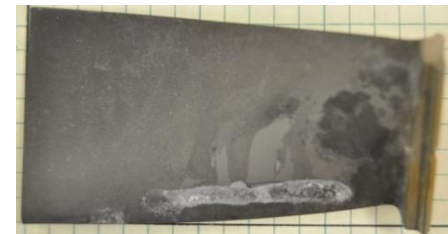
Uncoated, Pressure-Side



Uncoated, Suction-Side



Coated, Pressure-Side

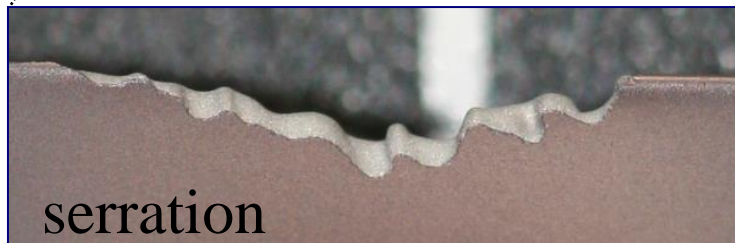
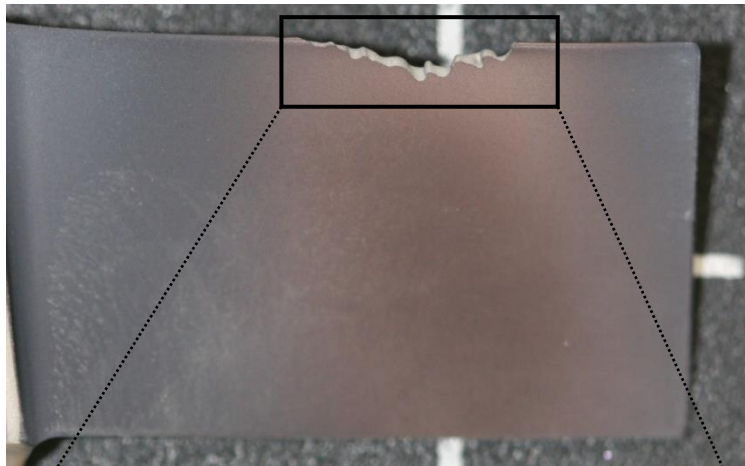


Coated, Suction-Side

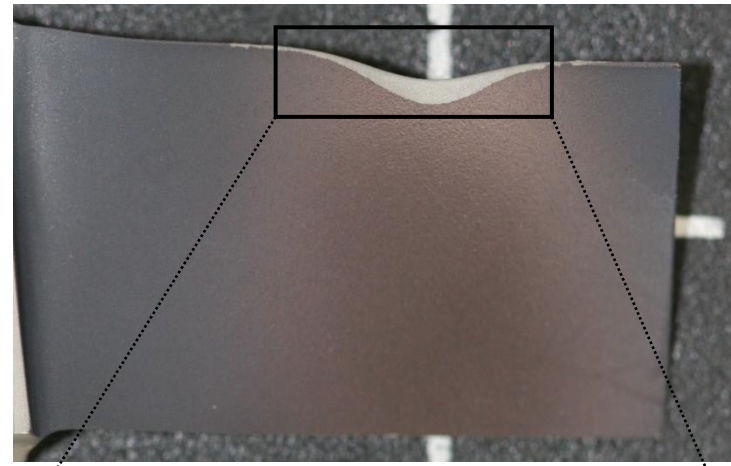
Erosion Test

- AED requirement that coating exposed to abrasive media could not result in Leading Edge Preferential Erosion (LEPER)
 - Typical of traditional hard coatings
 - Serrated LE or birdmouth features

LE Preferential Erosion ❌



Graceful erosion ✓



Erosion Test

- MCT conducted lab tests on parameters that impact LE erosion:

- Impingement Angle
- Particle Size
- Particle Velocity
- LE Radius
- Temperature
- Media Concentration



- Tests completed with MCT's Internal Erosion Rig Tests
- Confirmed **BlackGold**[®] coating's design capability to resist LEPER

Fatigue Test

- Honeywell conducted fatigue tests in 1Q CY14
 - 1st torsion test on uncoated and coated blades
 - Approved for limited field trial via Airworthiness Impact Statement
 - Final report to be issued
- Innovative Test Solutions conducting HCF tests in Aug 2014
 - 1st bend test on 12 uncoated and 12 coated 1st stage blades

Field Trial

- Leverage a scheduled Degraded Visual Environment (DVE) field trial for MH-47 Special Ops in April 2014
 - Uncoated and coated engine
 - Coated engine has two (2) uncoated blades per stage
- DVE field trial in Yuma, AZ
 - 35 hours completed in DVE
 - MH-47 test aircraft continuing to fly in desert environments
- Engine inspection scheduled at Ft. Campbell, KY for Nov '14
 - Estimate 200+ operational hours with coated engine



**Pending teardown inspection, engine performance and ROI analysis
conduct further FSE, implement coating or conclude program**