

# **Kinetic Metallization**

**Application of Alternative Wear-Resistant Metallic Coatings for  
Landing Gear and Aerospace Components**

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# Overview

- Alternatives for Hard Chrome Coatings
- Introduction to **Kinetic Metallization**
  - Overview of Process
  - Technical and Cost Advantages
  - Kinetic Metallized WC-Co Coatings
  - Kinetic Metallized MCrAlY Coatings

# HC Alternatives

- Executive Order EO13148
  - All Federal Agencies
  - Toxic Chemicals, Hazardous Substances, and Pollutants Reduced by 50% by 12/31/2006
  - Applies to Hard Chrome and Chromate Conversion Coatings

# US Organizations

- Hard Chrome Alternatives
  - PEWG & JPCC (DoD)
    - Propulsion Environmental Working Group
    - Joint Propulsion Coordinating Committee
  - HCAT (Hard Chrome Alternative Team)
    - PEWG, ESTCP
    - JG-PP (Joint Group-Propulsion Prevention)
    - SERDP (DoD, DoE, EPA)
      - Strategic Environmental R&D Program

# HC Alternatives

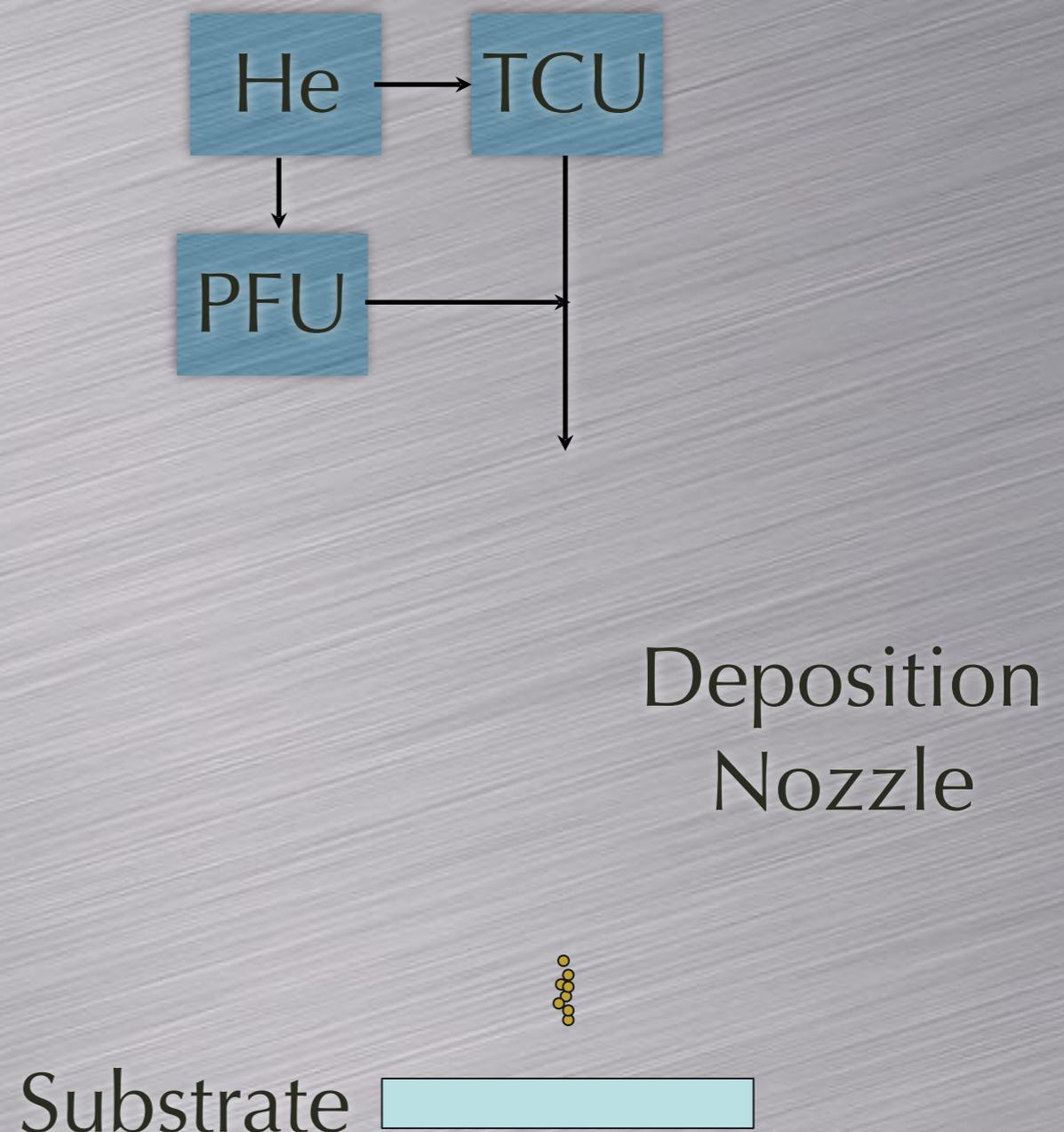
- Potential Alternatives for Wear Resistance
- Coatings: WC-Co and MCrAlY
  - HVOF Process
  - Spark Etch and EB-PVD Process
  - **Kinetic Metallization Process**

# Kinetic Metallization

- Impact Consolidation Process
  - Feed-stock: fine powder
  - Accelerant: inert light gas
- Solid-state Consolidation
  - No Bulk Melting
  - No Liquid Chemicals
- Environmentally Innocuous
  - No Particle or Hazardous Gas Emission

# KM Process Flow

- Powder fluidized using pressurized He gas (PFU)
- Powder/gas mix thermally conditioned to improve deposition efficiency (TCU)
- Deposition nozzle produces highly collimated spray pattern
- Area coverage using X-Y rastering of nozzle and/or rotation of substrate



# KM-CDS

First KM-CDS Shipped!!

Buyer: US Naval Academy

Located: NAVSEA-Carderock

- Coating Development System
- Desk sized
- Production unit
  - Same footprint
  - Remove spray enclosure

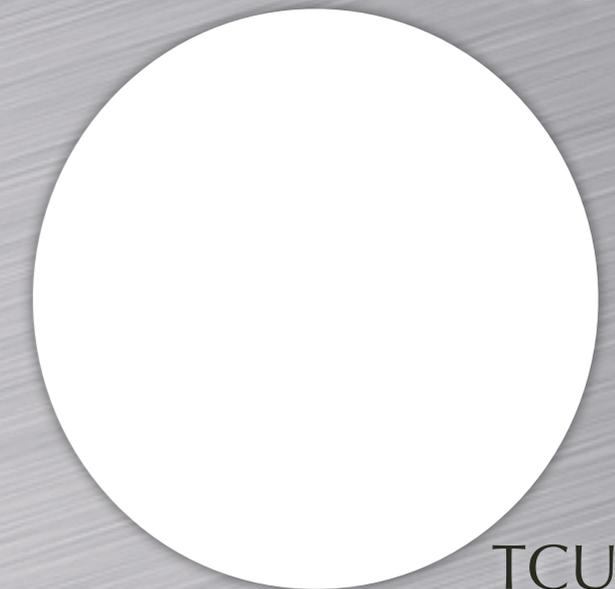


# KM Critical Components

- Powder Fluidizing Unit
- Closed-loop mass-loss control
- Thermal Conditioning Unit
- Low power
- Deposition Nozzle
- Friction compensated



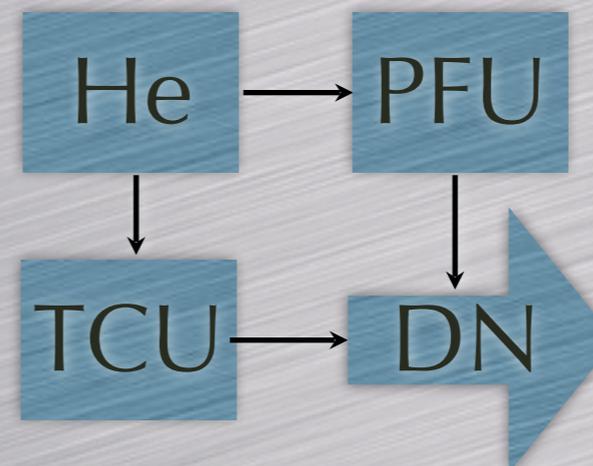
PFU



TCU



DN



## PFU Set Point

lb/hr

## TCU Set Point

deg F

## Width

in

## Step Size

in

## Length

in

## Sweep Velocity

in/s

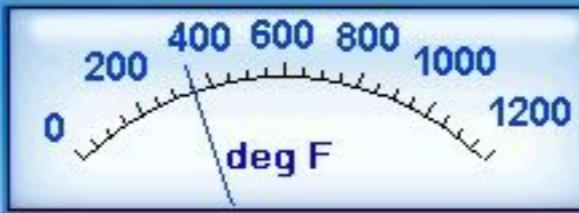
## Strokes/Step

## Layers

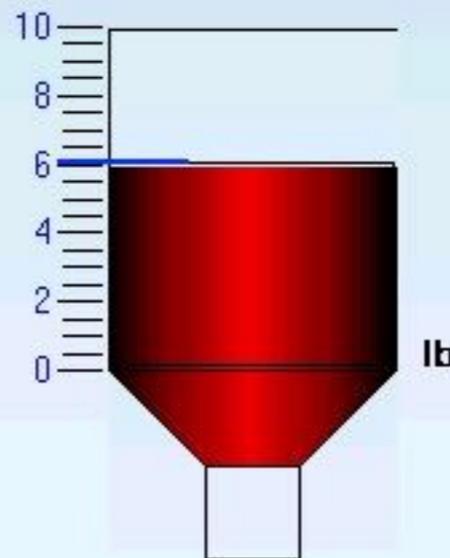
## PFU Actual



## TCU Actual



## Powder Weight



Initial  
 lb

Final  
 lb

PFU Active



PFU ECV



TCU Active



TCU ECV



## Operator Name

## Test Name

## Description

**START**

## Preview



Powder Flow



Motion

PFU Heat



## Units

English



SI

# KM Robotic Control

- Compatible with any robot
- 5-pin connector provides
  - All KM power/control interface



# KM Nozzle Design

- Nozzle Anatomy

- Friction Compensated Sonic Nozzle

- Reference: Session 2: AeroMat 2004

- “Kinetic Metallization Process and Coating Development System” Howard Gabel



# KM Examples

- Wear and Corrosion Resistant Coatings
  - WC-Co on High Strength Steels & Al Alloys
  - MCrAlY on Steel and Superalloys

# KM WC-Co Quality

- Highly Uniform
- WC 3- $\mu\text{m}$  Average
- Smooth Interface

# KM WC-Co Quality

KM WC-Co

HVOF WC-Co

# PEWVG Review

- Endorsed by OC-ALC and DoD JPCC
- Assess and verify KM for
  - Repair and manufacturing GTE components
  - GEAE Specification F50TF71
- Request AF Materiel Command, FY05 environmental funding



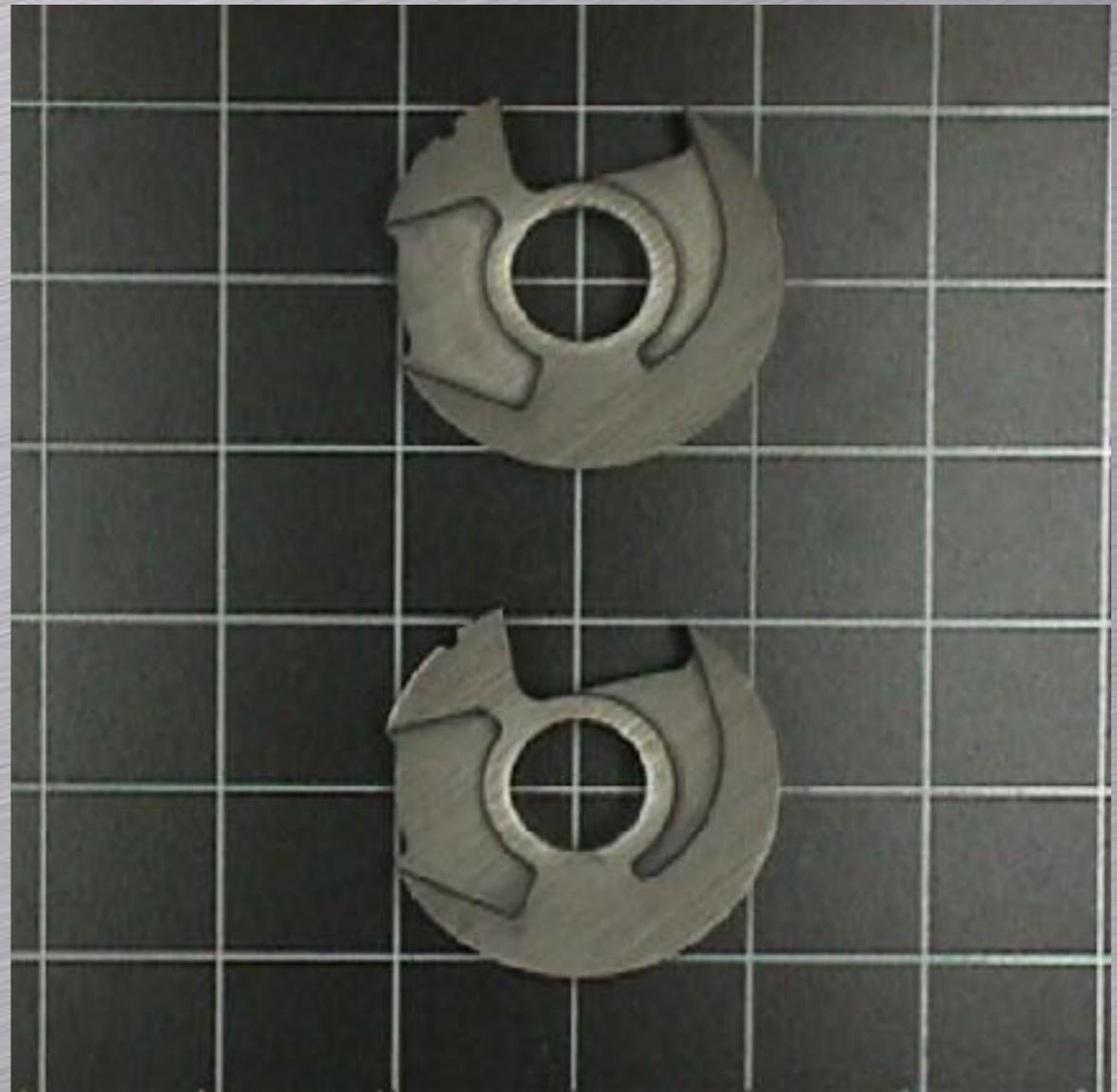
# KM WC-Co Coatings

## ● Wear Application

- Pump Guide Facing
- Aluminum Alloy Disk
- 5-6 mils Thick
- Grind/Polish 32  $R_a$

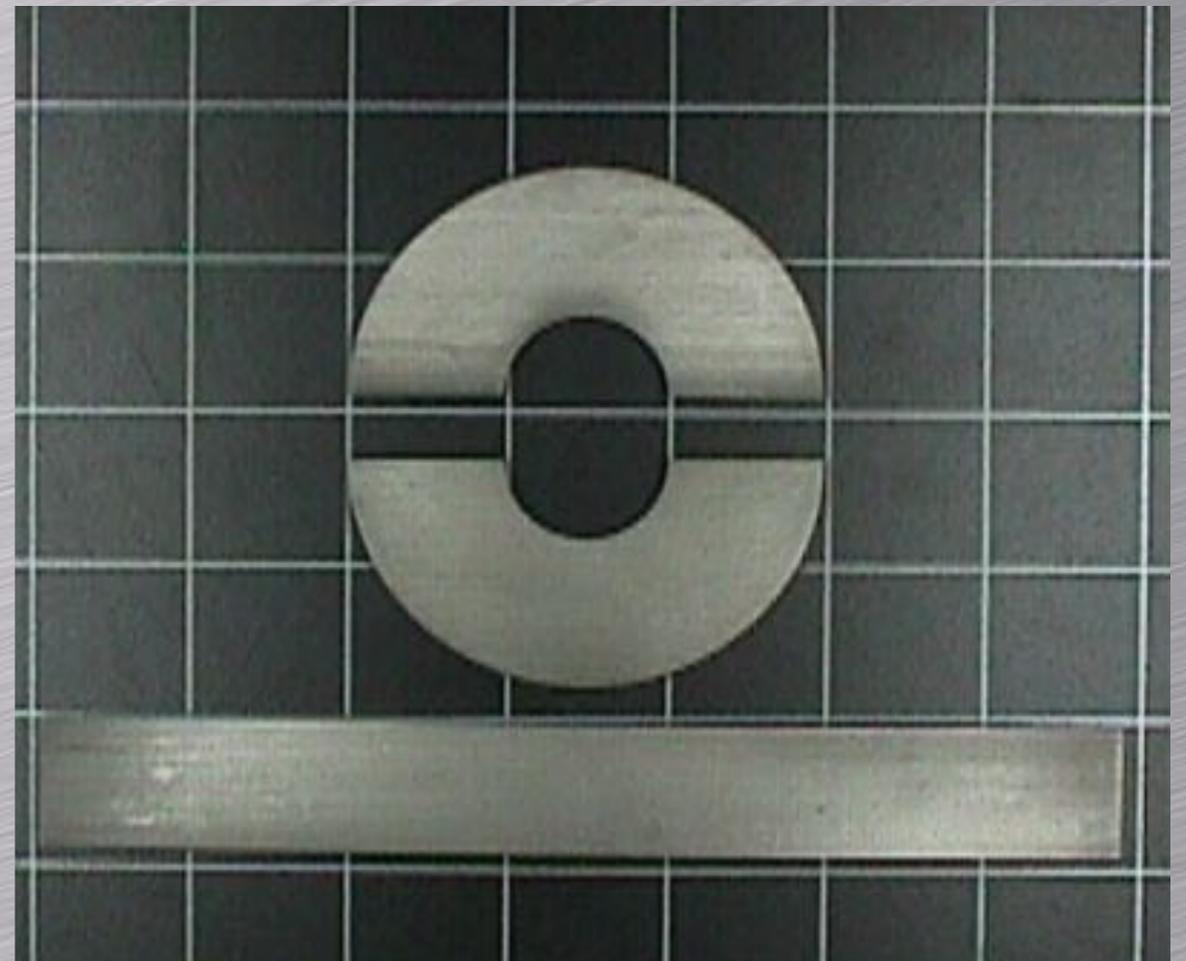
## ● Aerospace Customer

- Parker Aerospace



# KM WC-Co Coatings

- Wear Application
  - Demo of Oblique Angle
  - KM Applied at 45°
  - 5 mils Thick
  - Ti & Al Alloy Substrates
- Aerospace Customer
  - Hamilton Std. UTC



# KM WC-Co

## ● Borehole Drill Bit Heads

- Wear resistant WC-Co
- Applied to steel surfaces
- Improved adhesion over Detonation Gun Coatings



# NiCrAlY on Cu Alloy

- KM Process
  - Low Temperature on Cu
  - Inert Gas Applicator
- Rocket Engine Coating
  - Oxidation Resistant

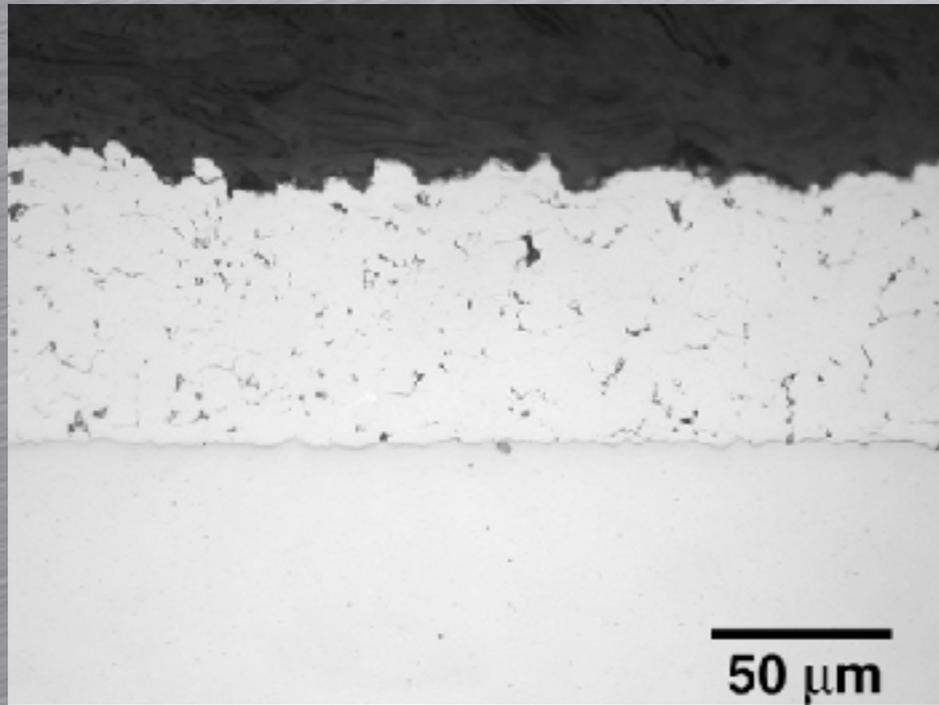
# CoNiCrAlY- Waspaloy

## ● KM Process

- Low Temperature
- No Grit Blast
- No Masking
- Low Cost

# The KM Alternative

KM NiCrAlY



HVOF CoNiCrAlY

Process	Coating Composition	Substrate Material	Porosity	Adhesion Strength
<b>KM</b>	Ni-16Cr-6Al-0.5Y	Steel	2.3%	>10.5 ksi (1)
<b>HVOF</b>	Co-Ni-Cr-Al-Y	Waspaloy	5.4%	~10ksi (2)

(1) Failure in epoxy (Sebastian stud-pull test per ASTM C 633)

(2) Failure in coating (1.0" dia. epoxied loading fixture per ASTM C 633)

# Process Simplification

HVOF

Grit  
Blast

Pre-  
Heat



Cool  
Down

KM

Coat

# KM WC-Co Summary

<i>Eliminates</i>	<i>Enhanced</i>
Grit Blast	Fatigue resistance
Preheat	Throughput
High temperature overheating	Permits long spray dwell times
Cool-down	Throughput
Heat distortion	Usability
Masking	Throughput
Sharp transitions	Fatigue resistance
Porosity	Ductility
Oxide inclusions	Ductility, corrosion resistance
Explosive Gases	Safety

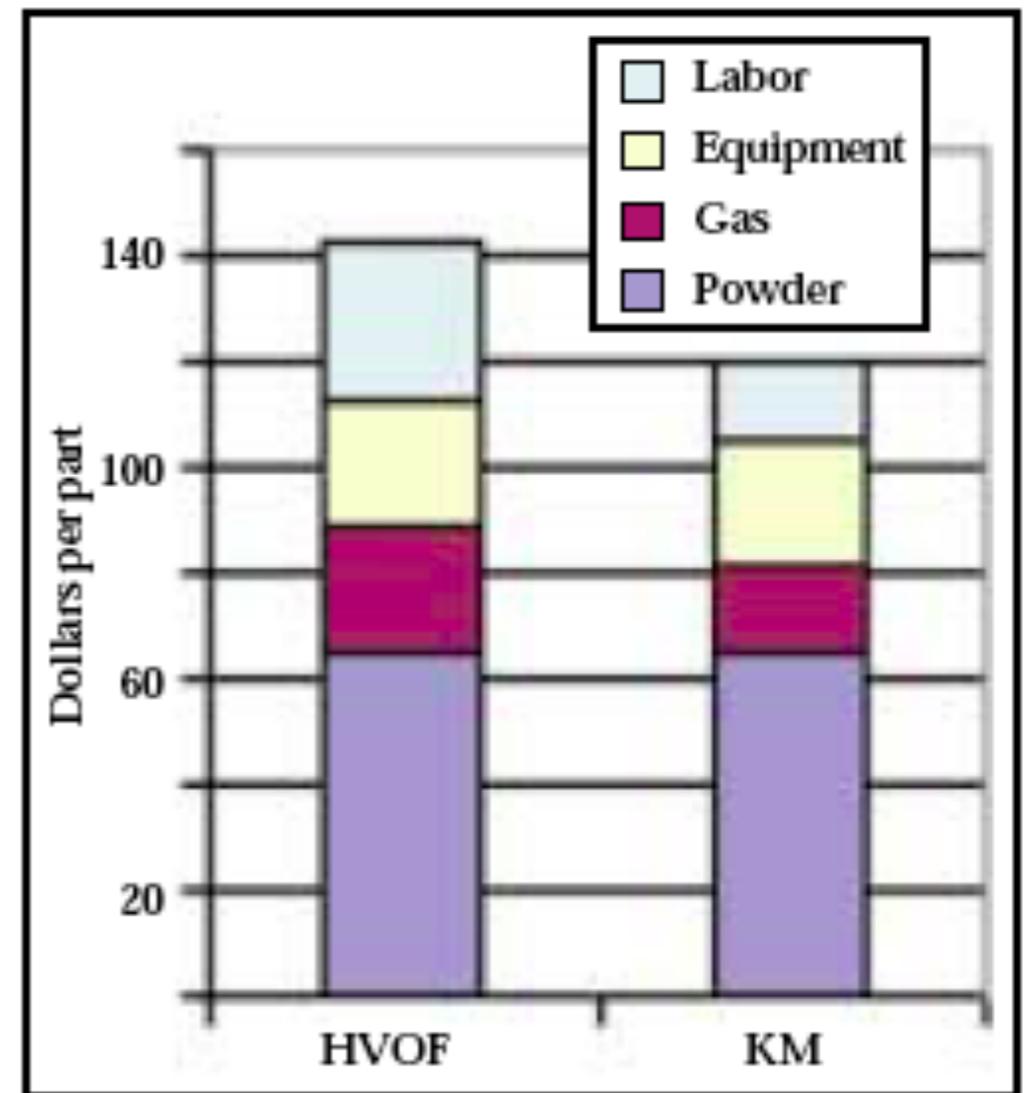
# KM vs. HVOF Costs

## Hypothetical Actuator

- Dimensions 36" x 4" OD
- Labor Rate @ \$17/hr
- 60% Deposition Efficiency
- Capital Equip - 7 Yr Life

## Adv. Materials & Processing

- May 2004 Issue
- Tech Spotlight



*Part cost summary, HVOF compared with kinetic metallization.*

# KM Future WC-Co

- Phase II AFRL Material Command
  - KM of WC-Co Selected in FY03 by AFRL
    - Material Performance per GEAE Specification F50TF71
    - Fatigue Evaluations in FY04
- Qualification Testing for Future Customers
  - Hamilton Std. UTC
  - Parker Aerospace
  - Conval, Inc.
  - Woodward Governor Co.

# KM Future MCrAlY

- Qualification Testing for Future Customers
  - Pratt and Whitney
  - Honeywell Aviation Services
  - HiTempCo
  - Solar Turbines