

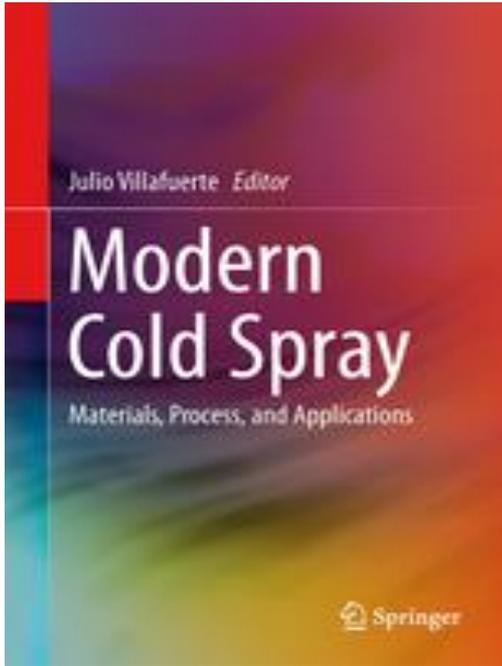
# Using Cold Spray to Add Features to Components



**Julio Villafuerte, PhD, P.Eng**

**June 23-24 2015**





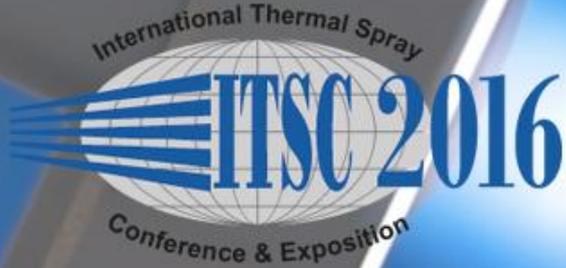
*Coming this August 2015*

# Modern Cold Spray Materials, Process, and Applications

Editor: Villafuerte, Julio

<http://www.springer.com/us/book/9783319167718>





**Thermal Spray: Fostering a sustainable world for a better life!**

May 10 – 12, 2016 | Shanghai / P.R. China



# OUTLINE

**Company Overview**

**Cold Spray**

**Additive Consolidation Applications**

**Food for thought**

**Questions**



# CenterLine (Windsor) Limited



- Privately held corporation, founded in 1957 with current annual sales > \$150M
- Over 250,000 sq ft. of manufacturing space & 700 employees
- Centered on **metal joining** and **metal consolidating** technologies from *components to turnkey solutions*
- Numerous patented products and proprietary brand products.

# Locations



- Machinery Division
- Automation Components Division
- Electrodes & Allied Products Division
- Supersonic Spray Technologies Division
- CenterLine Welding Products, Inc.
- CenterLine SE USA Sales Office

- CenterLine Mexico
- CenterLine-Seubert GmbH
- CenterLine Romania SRL
- CenterLine Brasil Ltda.
- CenterLine India Pvt. Ltd.
- CenterLine China (Oct 2013)



# Components to Turnkey

- ✓ Vertically integrated
- ✓ Uniquely supplies a complete range of products in support of a wide variety of metal joining and coating processes.



Custom Automation Systems

Standard Turnkey Automation Products



Actuators - Air, Air/oil, and servo

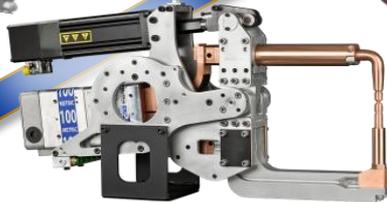


Consumables caps, electrodes, nut welding



Index Tables, Tooling & Fixtures

Weldguns (fixture, robotics, hand-held)



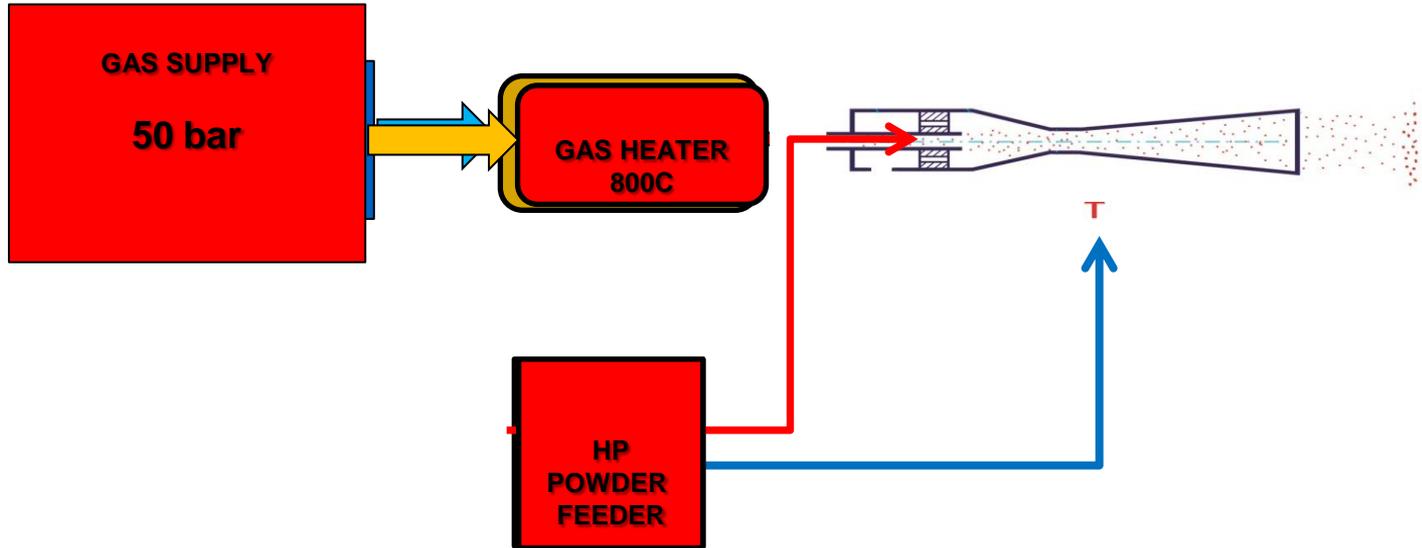
Cold Spray Systems



# Commercial Cold Spray Systems

UPSTREAM INJECTION

DOWNSTREAM INJECTION



# SST Cold Spray Guns

**SERIES P Portable**  
**250 psi – 3.8KW**



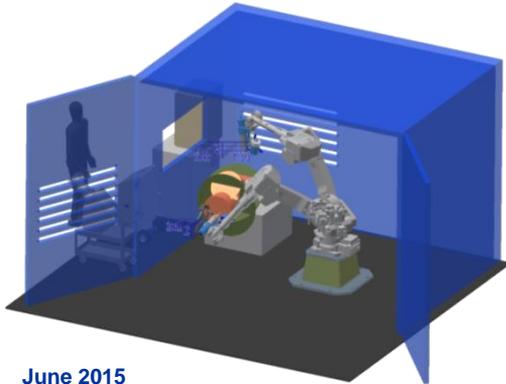
**SERIES P Robotic**  
**250 psi - 4.2KW**



**SERIES EP Robotic**  
**500 psi – 15 KW**



# SST Turnkey Spray Cabinets / Booths



June 2015

# SST Cold Spray Consumables & Auxiliary

## Consumables



## Auxiliary Equipment



## SST™ Powders



- Developed and manufactured by SST
- Made and stored in our environmentally controlled clean room



# OUTLINE

Company Overview

**Cold Spray**

Additive Consolidation Applications

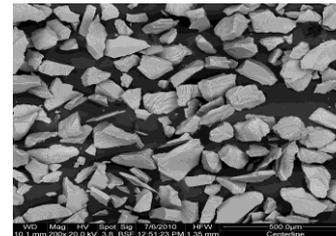
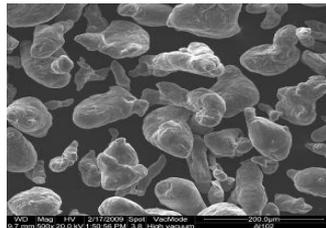
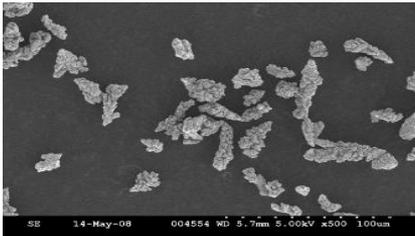
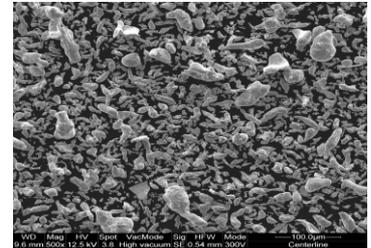
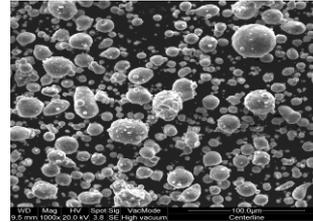
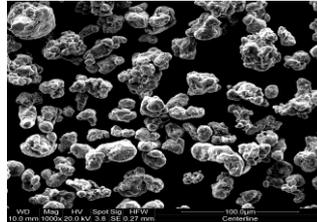
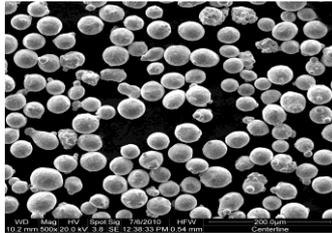
Food for thought

Questions



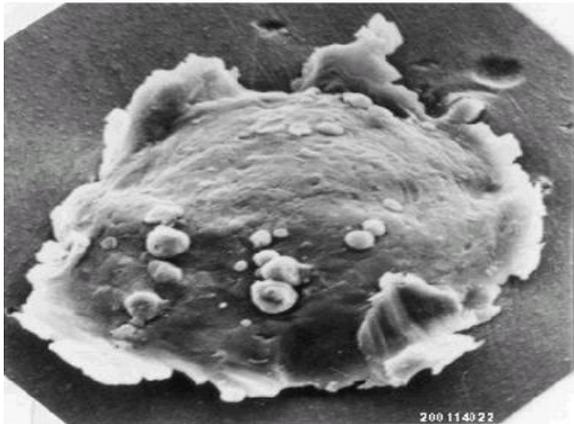
# Cold Spray

- POWDERS** of Pure Metals, Alloys, Metal /Metal, Metal /Ceramic, Metal/Cermet, Metal /Polymers
- Introduced into a cold, high speed gas jet and directed towards a substrate that can be Metal, Ceramic, Glass, Polymeric\* or Composite



# Cold Spray

- Kinetic energy of accelerated particles produces a combination of mechanical and metallurgical bonding upon impact with substrate



10µm

Operating temperatures  
are well below the  
melting points of coating  
and substrate materials

# Cold Spray Advantages

- **No Thermal Effects**
- **No Metallurgical transformations, phase change, grain growth**
- **No thermally induced distortion**
- **No Oxidation**
- **High Density (>99.5%) – controlled porosity**
- **Strain hardening**
- **No detrimental Residual Stresses**
- **Thick deposits, free forms**
- **Minimum surface preparation**
- **Well defined spray footprint – No overspray - No masking**

Company Overview

Cold Spray

**Additive Metal Consolidation Applications**

Food for thought

Questions

# Cold Spray Specifications

METRIC

MIL-STD-3021  
w/CHANGE 2  
4 March 2015  
SUPERSEDING  
MIL-STD-3021  
w/CHANGE 1  
13 July 2011

**DEPARTMENT OF DEFENSE  
MANUFACTURING PROCESS  
STANDARD**

**MATERIALS DEPOSITION, COLD SPRAY**



AMSC N/A

AREA MFFP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

June 2015



# Cold Spray Specifications

## Honeywell



GE  
Energy

- Honeywell Aerospace
  - Caterpillar Inc
  - GE Energy
  - Detroit Diesel
- Hamilton Sundstrand
- Sikorsky Aircraft Corporation



**Hamilton Sundstrand**

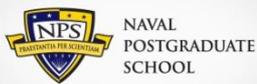
A United Technologies Company

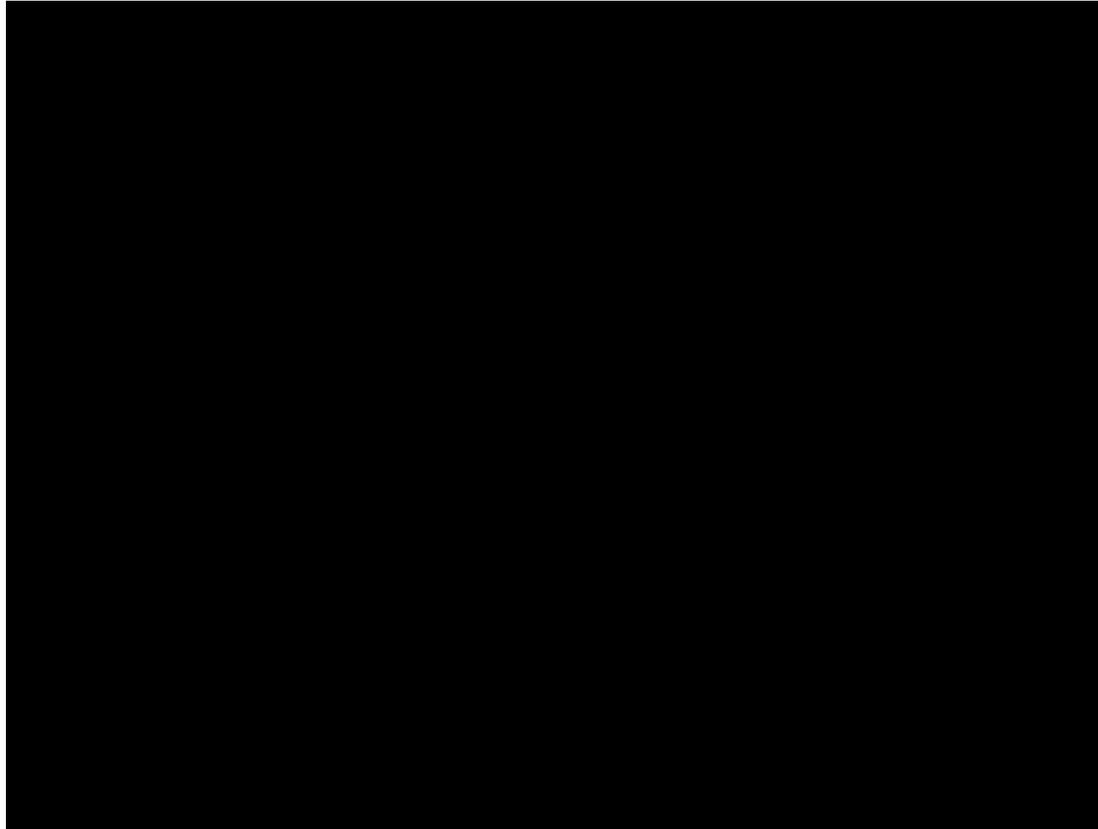


**Sikorsky**

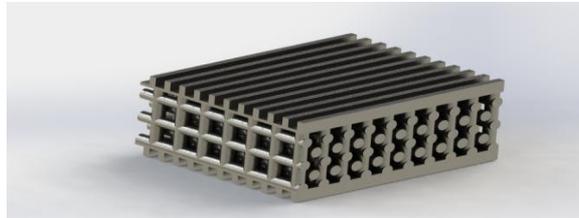
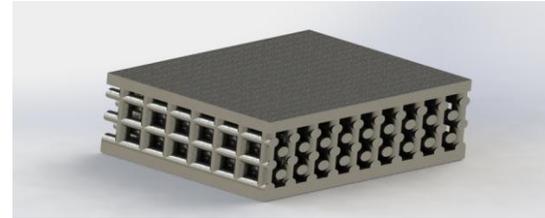
A United Technologies Company

# SST Cold Spray Users



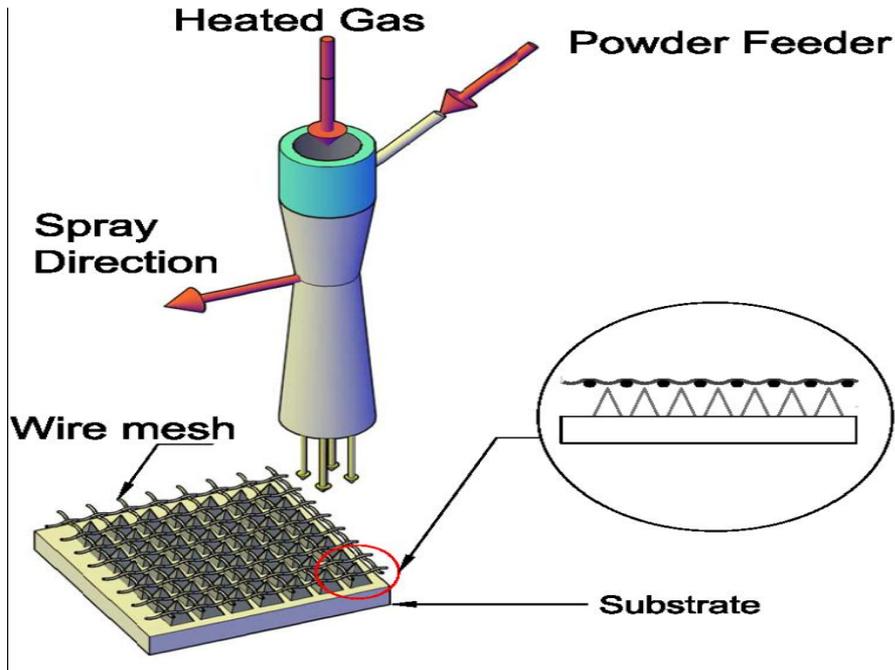


# Heat Exchanger Surface Features



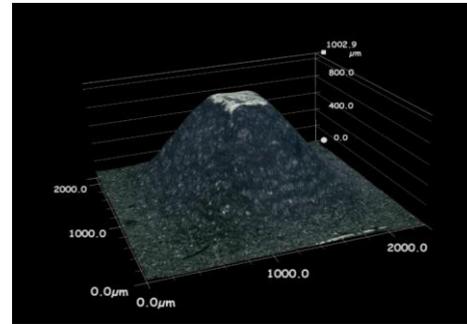
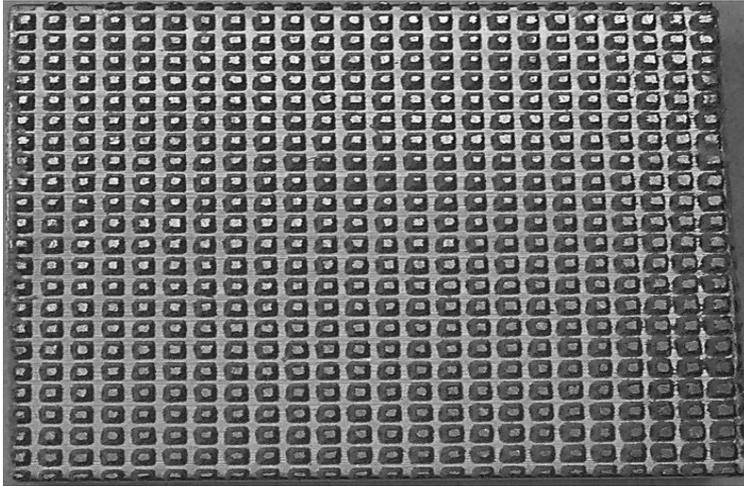
uOttawa

L'Université canadienne  
Canada's university



uOttawa

L'Université canadienne  
Canada's university



## The Problem

- Pre production Cam Shaft Bearing Cap.
- Cap Lift of and Oil Leak (see Figure 1).
- No thermal distortion to the component during the corrective process.

## The Solution

- The SST Cold Spray coating technology was selected.
- First surface prepared using 80 grit aluminum oxide blast media
- Then sprayed with CenterLine's SST-A0027 aluminum blend material (see Figure 2).



Figure 1 – Original Bearing Cap

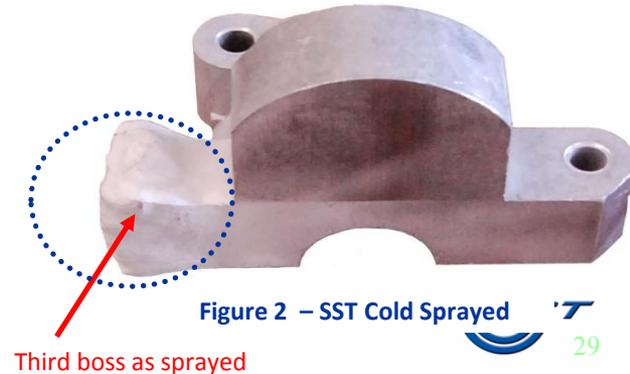


Figure 2 – SST Cold Sprayed

Third boss as sprayed

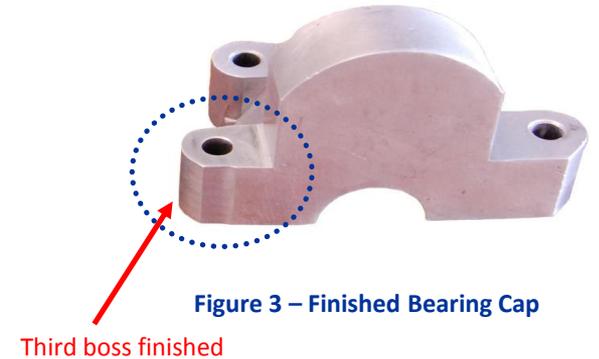
## Bearing Cap Modification

## The FINISHING

➤ Finish machining process was performed by CenterLine (see Figure 3).

## Customer Benefits

- final test components passed the customer's quality and performance specifications
- The rapid turnaround time allowed the initial production schedule to be maintained
- Saving the customer 8 to 10 weeks in their engine test program



## The Problem

- Fully machined Engine blocks
- Customer needed threaded bosses for Knock sensor testing (see Figure 1).
- No thermal distortion to the component during the corrective process.

## The Solution

- The SST Cold Spray coating technology was selected.
- Then sprayed with CenterLine's SST-A0027 aluminum blend material in four locations (see Figure 2).



Figure 1 – Machined Engine block



Added four bosses

Figure 2 – SST Cold Sprayed

## Sensor Bosses on Engine Block

## The FINISHING

➤ Finish machining process was performed by CenterLine (see Figure 3).

## Customer Benefits

➤ The customer has determined where the best location for the sensor is and will modify more blocks with the single boss for further testing. This process salvaged the machined blocks with minimal delay in the test program saving them Time and Thousands of dollars

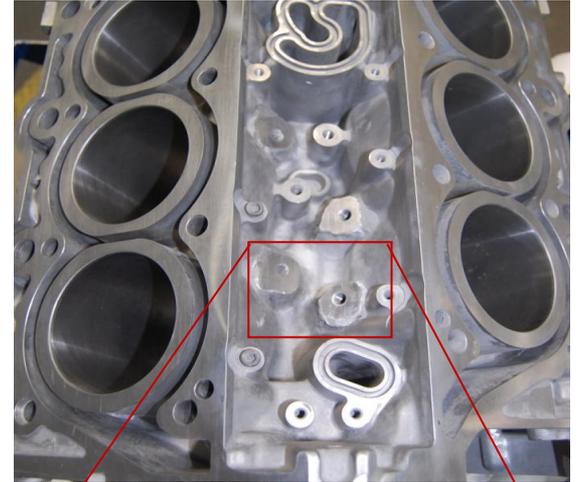
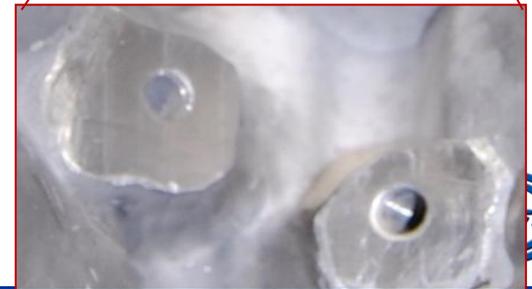


Figure 3 – Spot faced , drilled, & Tapped

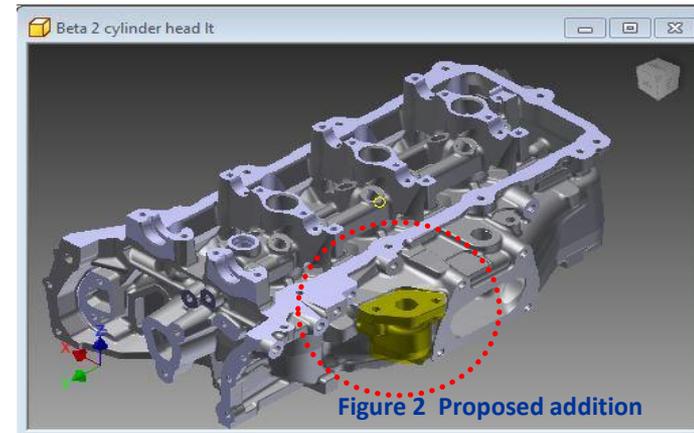
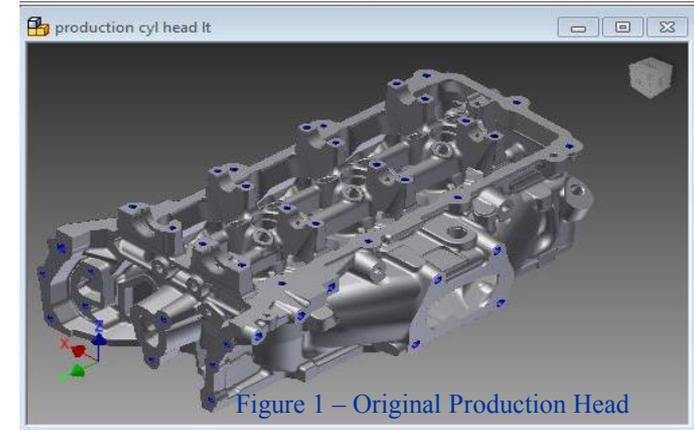


## The Problem

- Pre production Head .
- Without EGR Boss Flange(see Figure 1).
- Proposed EGR Flange addition (see Figure 2).
- No thermal distortion to the component during the corrective process.

## The Solution

- The SST Cold Spray coating technology was selected.
- Then sprayed with CenterLine's SST-A0027 aluminum blend material
- Build up Area and machine to math model



## Build up flange area

- With a Manual Cold Spray Gun the Flange area was added (see Figure 3 & 4).



Figure 3 – Manual Build up of Area

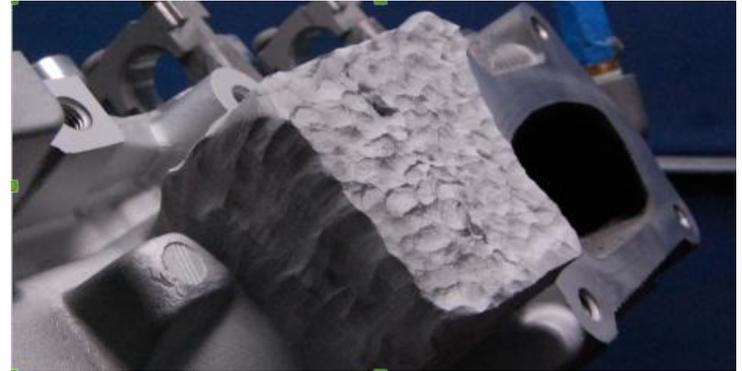


Figure 4 – Manual Build up of Area

## EGR Boss Addition

## The FINISHING

- Finish machining process was performed by CenterLine (see Figure 5 & 6).
- Cross drilled and Taped for pipe plug



## Customer Benefits

- The use of an existing production part saved a lot of time and money to produce a prototype part

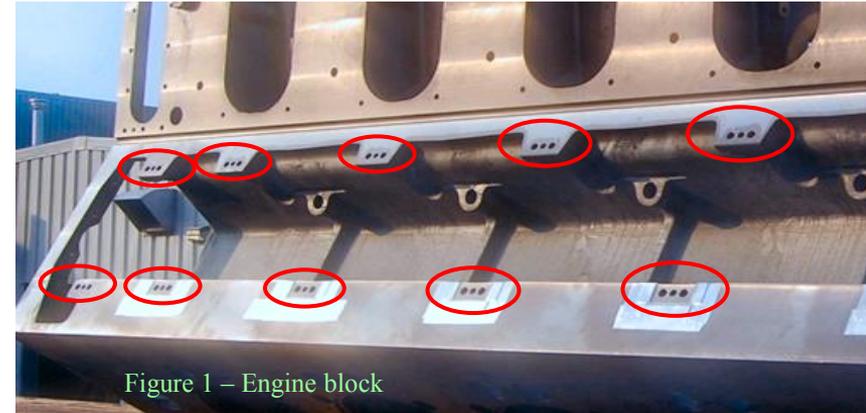


## The Problem

- Cam Shaft Mounting surfaces out of Spec by .015”
- Block was fully machined
- No thermal distortion to the component during the corrective process.

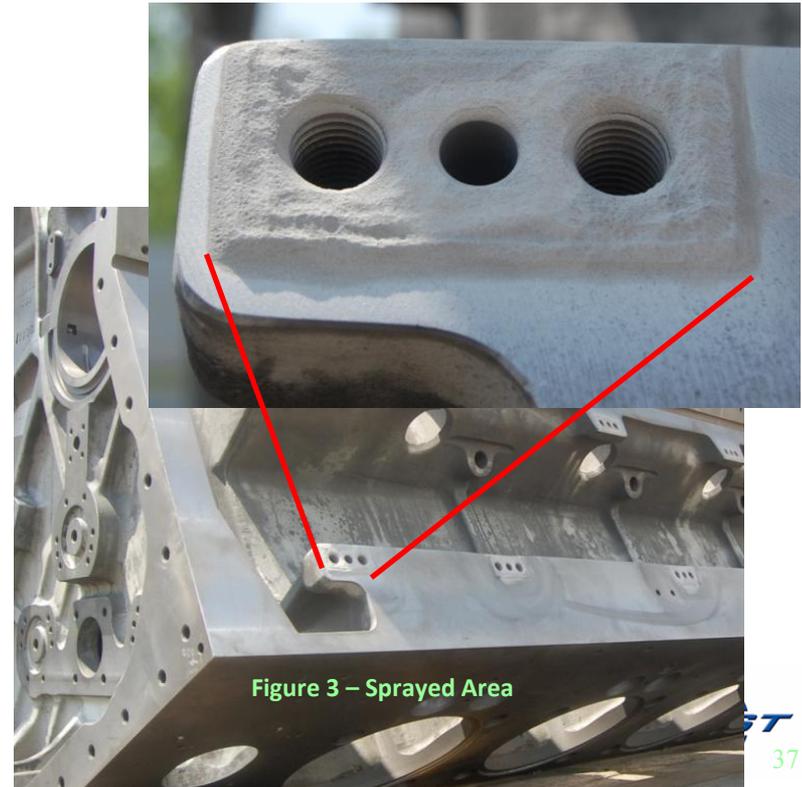
## The Solution

- The SST Cold Spray coating technology was selected.
- Then sprayed with CenterLine’s SST-N0056 Nickel blend material (see Figure 2).



## Customer Benefits

The customer was extremely pleased with the final result of this application since the repair did not introduce component distortions, and the part could be finished using standard machining practices. (see Figure 3).



Company Overview

Cold Spray

Additive Metal Consolidation Applications

**Food for thought**

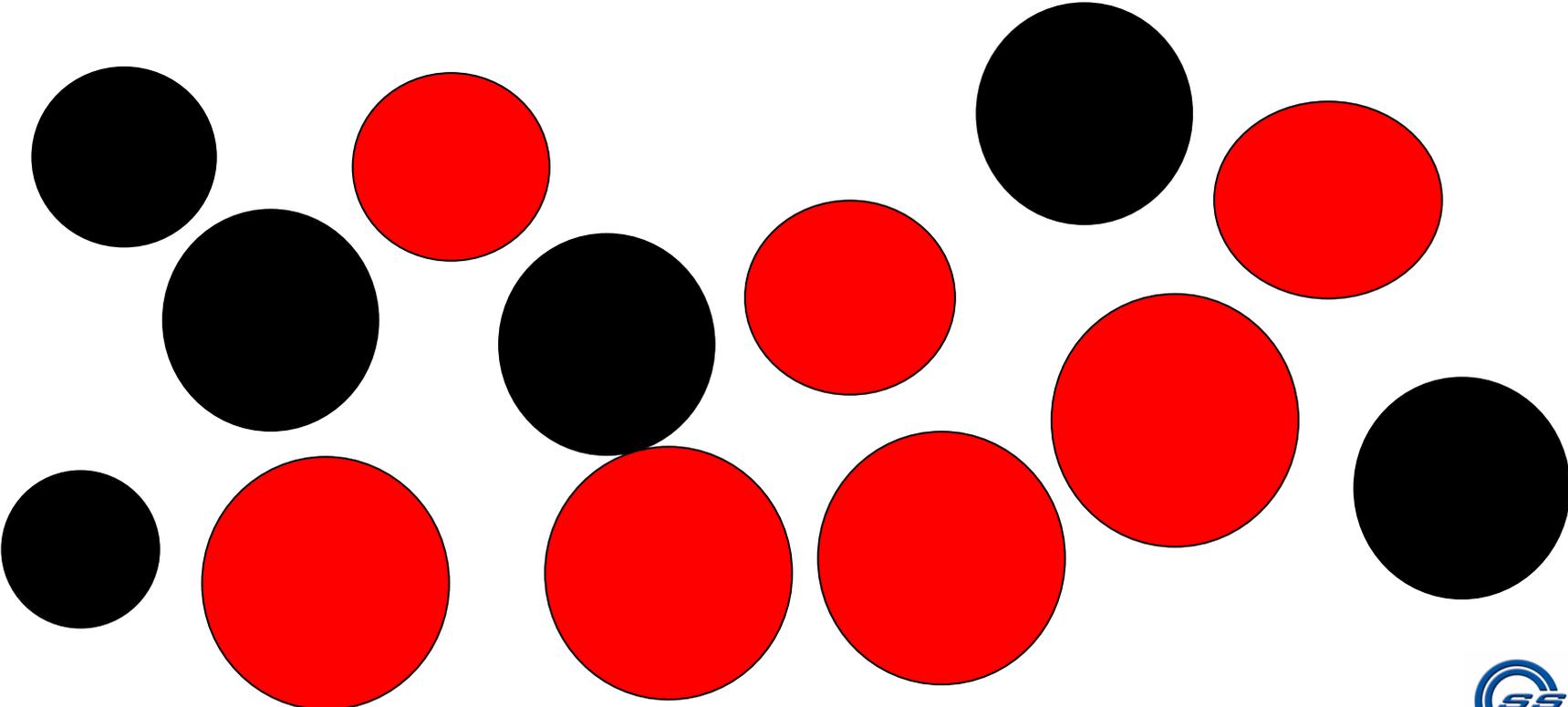
Questions

# Cold Spray-ability and powder engineering

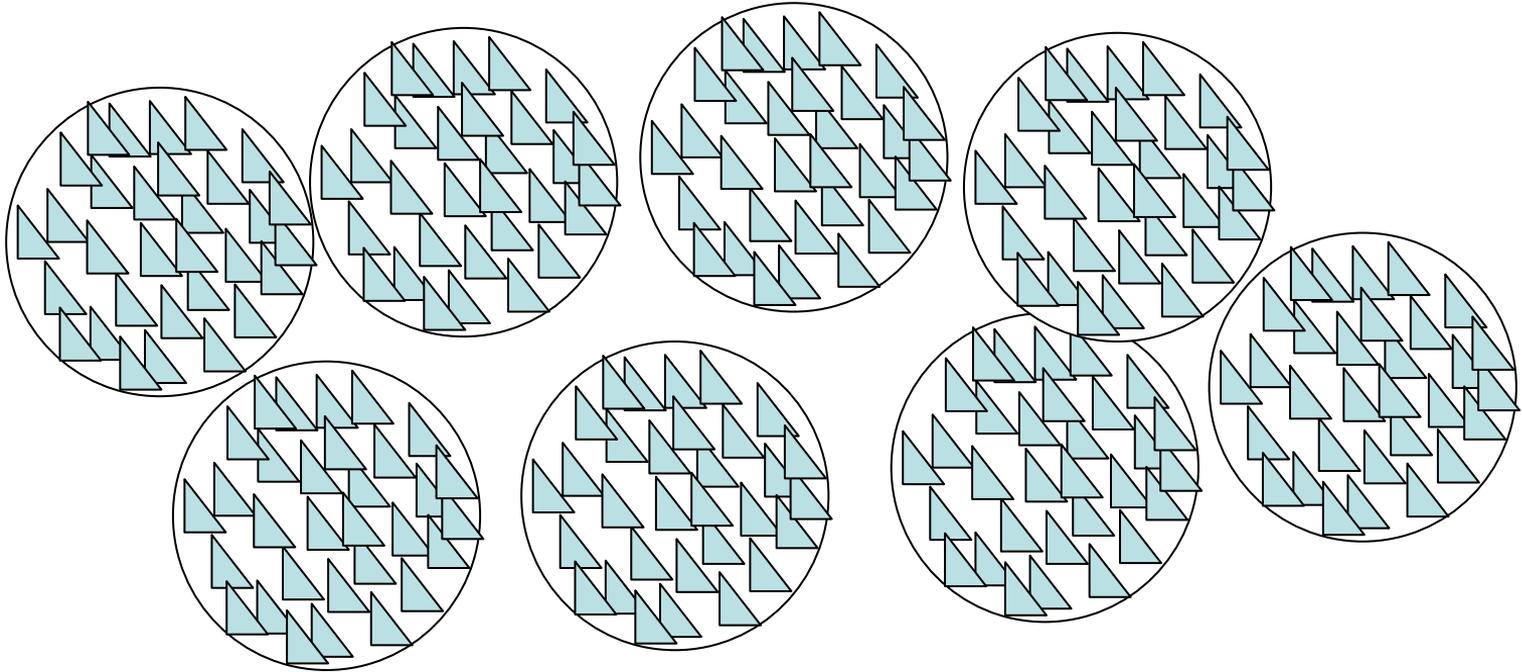
June 2015



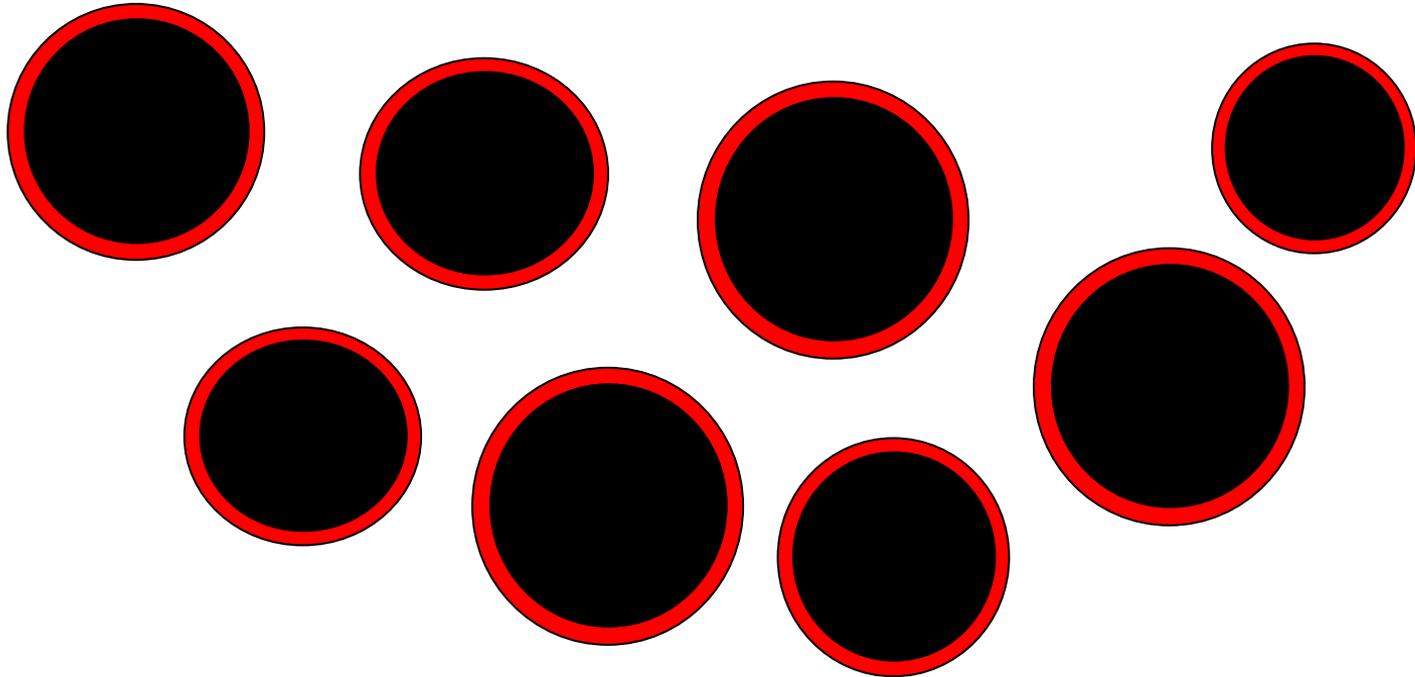
# SOLID PARTICLES



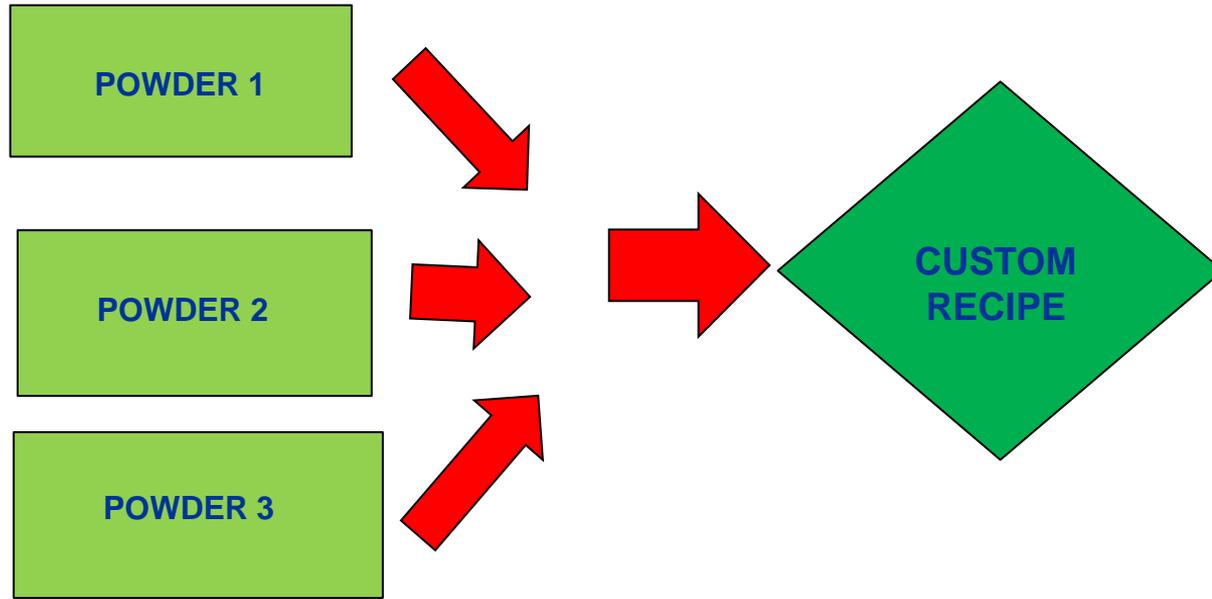
# AGLOMERATES



# COATED PARTICLES

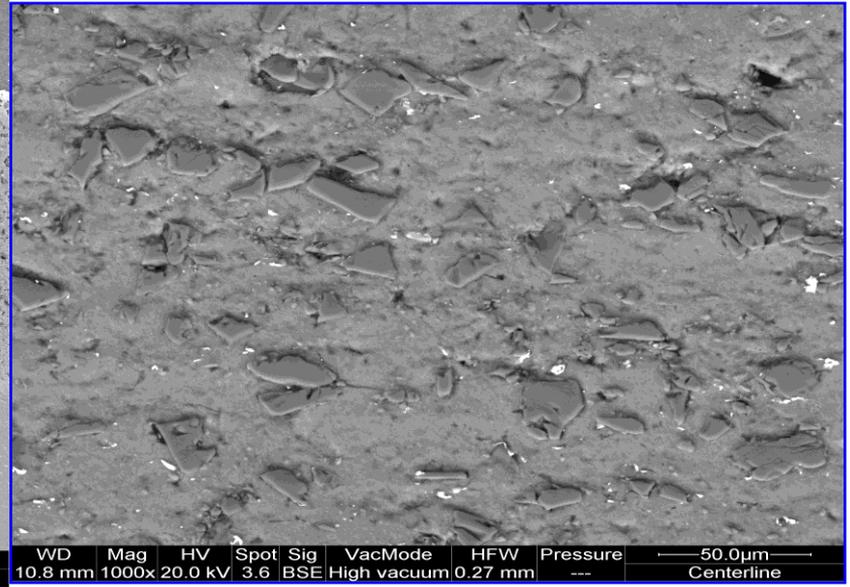
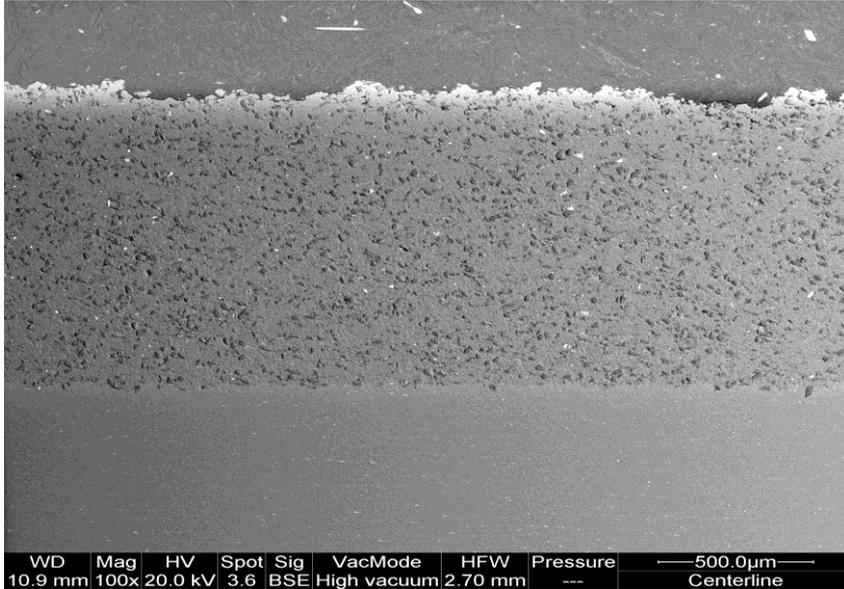


# BLENDING



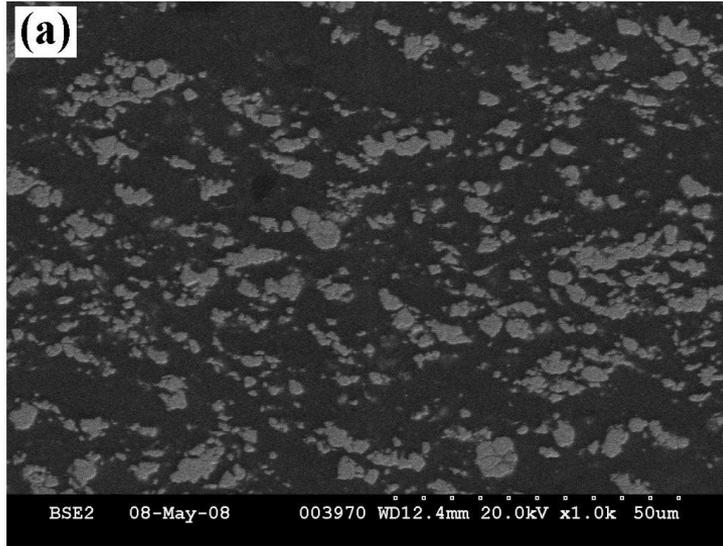
# Al-Al<sub>2</sub>O<sub>3</sub> (SST A0050)

Compressed Air 95-110 psi  
 Temperature 350 – 450C

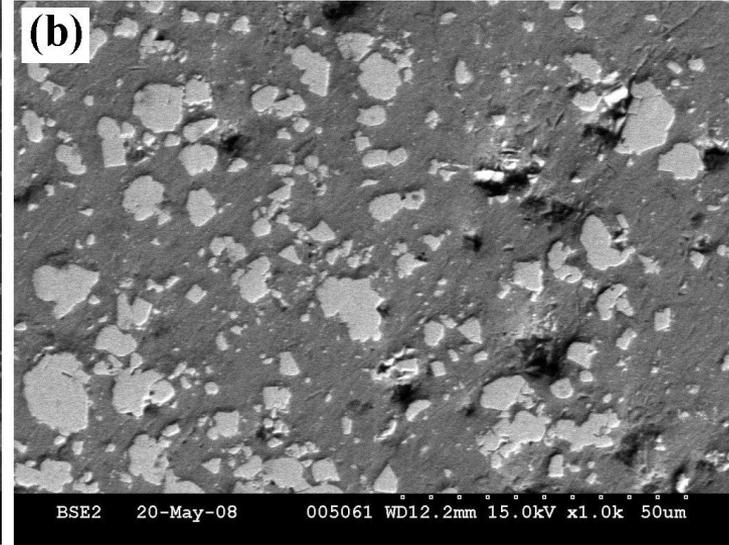


# Coated WC Particles

Compressed Air 80-90 psi  
Temperature 375 – 550C



Aluminum coated WC particles (14-25 micron)

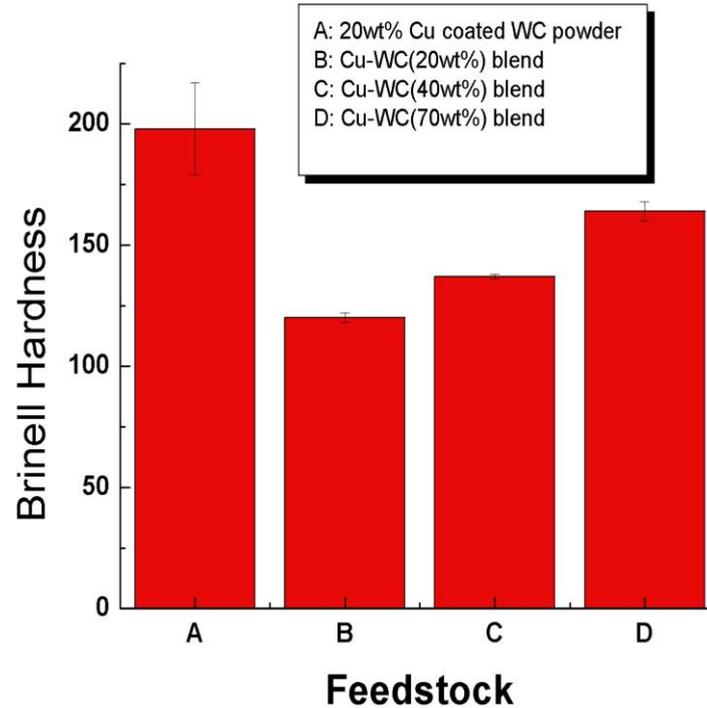
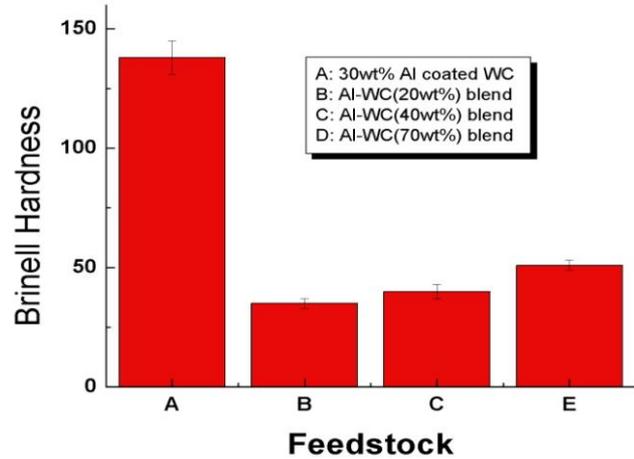


Copper coated WC particles (14-25 micron)

*J. Wang, J. Villafuerte, Low pressure cold spraying of tungsten carbide composite coatings", Adv. Mater. Process. ASM International 2009, 167 (2), pp 54-56*



# Coated WC vs Blends



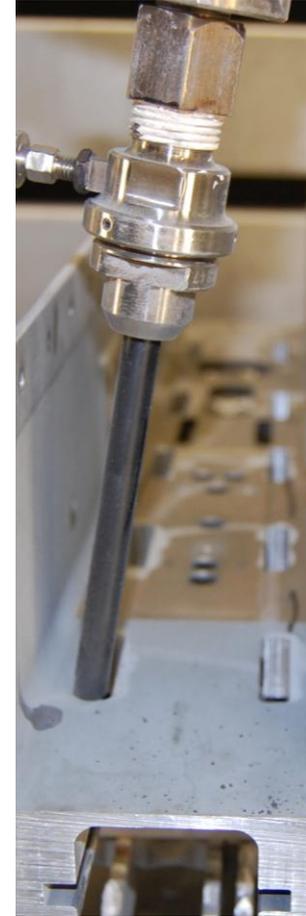
# How small is small for Cold Spray Nozzles? for precise deposition of metals

June 2015



## SST 4 mm exit diameter nozzle

- *1.5 mm DeLaval Orifice*
- *4.0 mm Exit diameter*



# Summary

- Cold spray is another method for metal consolidation with a special appeal to additive manufacturing because of its low temperature application
- At its current state, cold spray may fit into the 3D additive restoration world to near shape forms, where a finishing machining operation is required to complete the task.



# QUESTIONS?

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