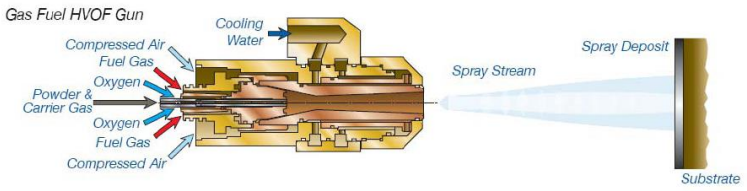
Thermal Spray Process Training



Thermal Spray Training

Sample Outline

2020

Introduction

- Sauer Engineering
- John P. Sauer P.E.
  - Principal Consultant and Trainer
  - 20 yrs in Thermal Spray
    - 20 yrs in Coating Evaluation In conjunction with IMR Test Labs
    - 12 years in Coating Processing
  - Can understand and train/consult both in the lab abs on the spray floor
- Other trainers with experience as needed

Philosophy

- Theory training in classroom
- Hands-on training in the booth
- 3 days of theory
- 2 days of hands-on (two sessions)
- Training based on *why* not how philosophy
  - How re-inforces the button pusher idea not explaining why things are done
  - The why philosophy explains the steps along the way and makes the thermal sprayer a problem solver
- EDUCATION NOT JUST TRAINING

Schedule

- Day 1
  - Morning
    - General Lecture
    - TS Lecture
  - Afternoon
    - Grit blasting and cleaning
    - Go to shop floor
  - Q and A Session
- Day 2
  - Morning
    - Plasma
    - Plasma Lessons
  - Afternoon
    - Typical Gun Rebuild
  - Q and A Session

Schedule

- Day 3
  - Morning
    - Process Control
    - Plasma Booth Hands-on
  - Afternoon
    - Process Control Hands-on
    - Maintenance
  - Wrap-up Session

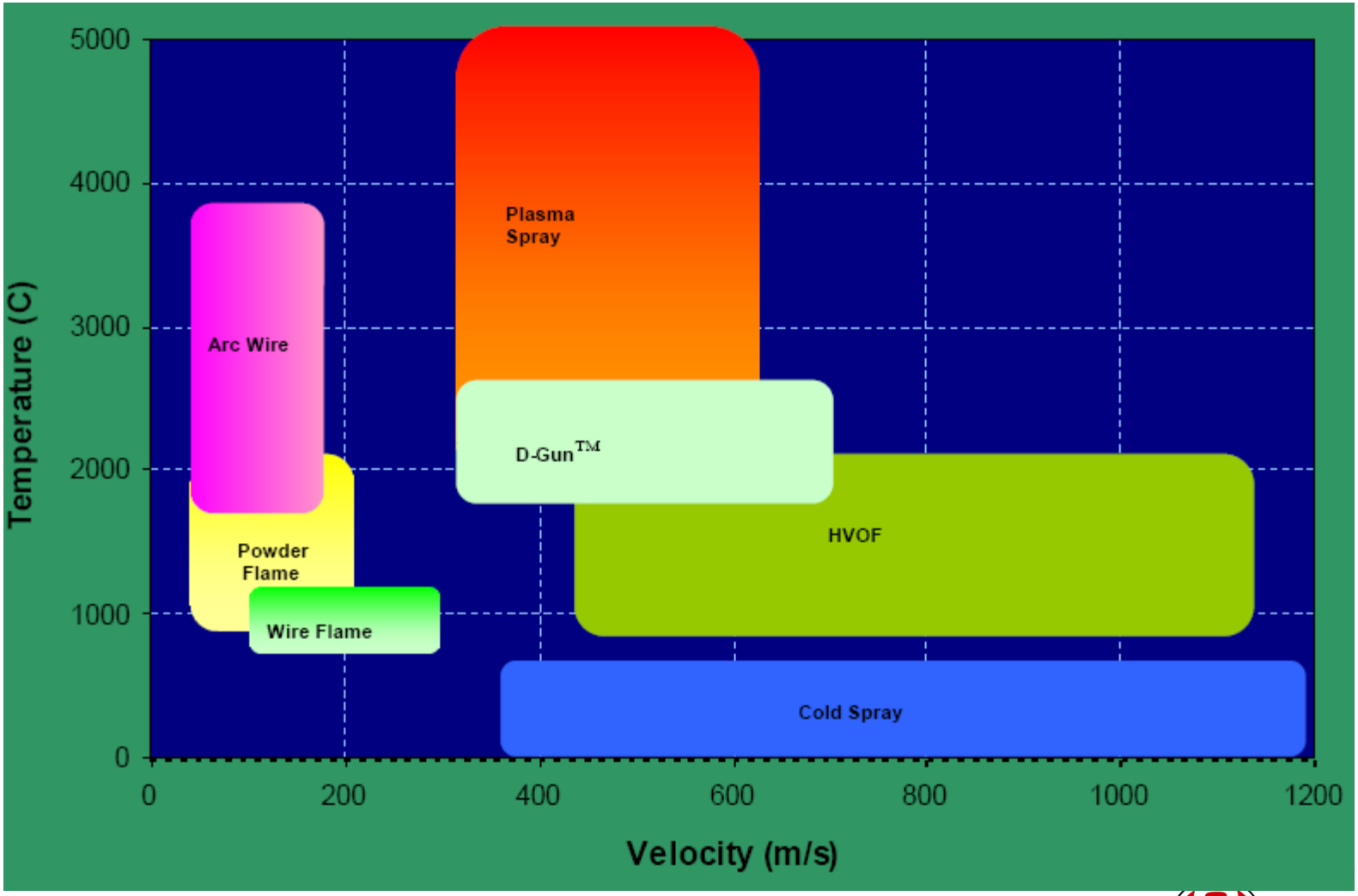
Schedule-Hands-on

- Day 4
  - Morning
    - Mask Cool
    - Mask Cool Hands-on
  - Afternoon
    - HVOF Overview
    - HVOF Systems
  - Q and A Session
- Day 5
  - Morning
    - HVOF Gun Re-build
    - Powder Hopper Re-build
  - Afternoon
    - HVOF/Plasma Hands-on
    - Facility Problems
  - Wrap up session

Outline

- General theory of Thermal Spray (TS)
  - Low velocity combustion
  - Plasma
  - Wire
  - HVOF
  - Other

HVOF

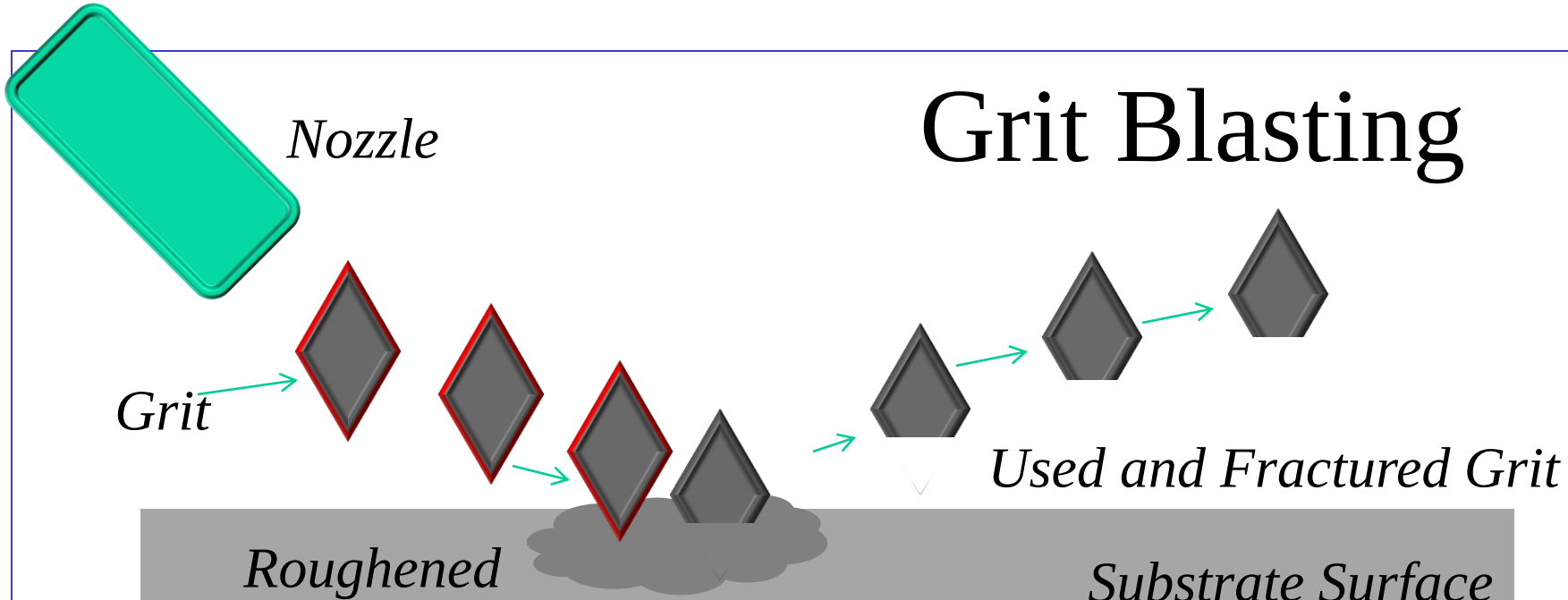

5000
4000
3000
2000
1000
0
Temperature (C)
0
200
400
600
800
1000
1200
Velocity (m/s)
Plasma Spray
Arc Wire
D-Gun™
HVOF
Powder Flame
Wire Flame
Cold Spray

Outline

Grit Blast and Cleaning Equipment

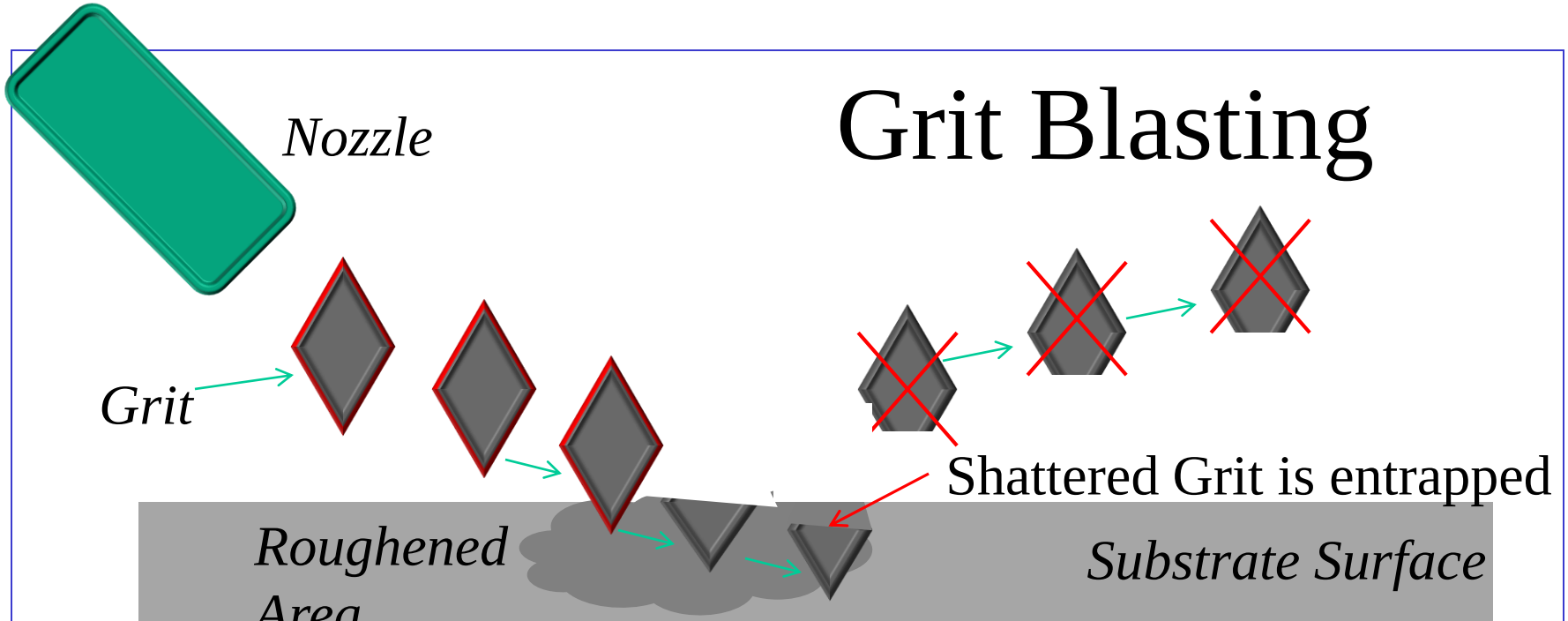
- Cleaning
  - How?
  - With what?
- What type?
  - Air pressure control
- Grit size
  - Control of grit
  - Filtering
- Surface roughness

Grit Blasting



New grit pushes the used grit from the surface in a repetitive blasting motion like skipping rocks

Grit Blasting



When grit use in is not controlled
and the grit breaks down, smaller particles
which have fractured can be pushed into
the substrate by bigger particles-no skipping

Outline

- Plasma
  - General Overall Design
  - Create a plasma
  - Different types of gases-combinations
  - Many different gun designs
  - Control of process
  - Different types of injection
  - Powder delivery

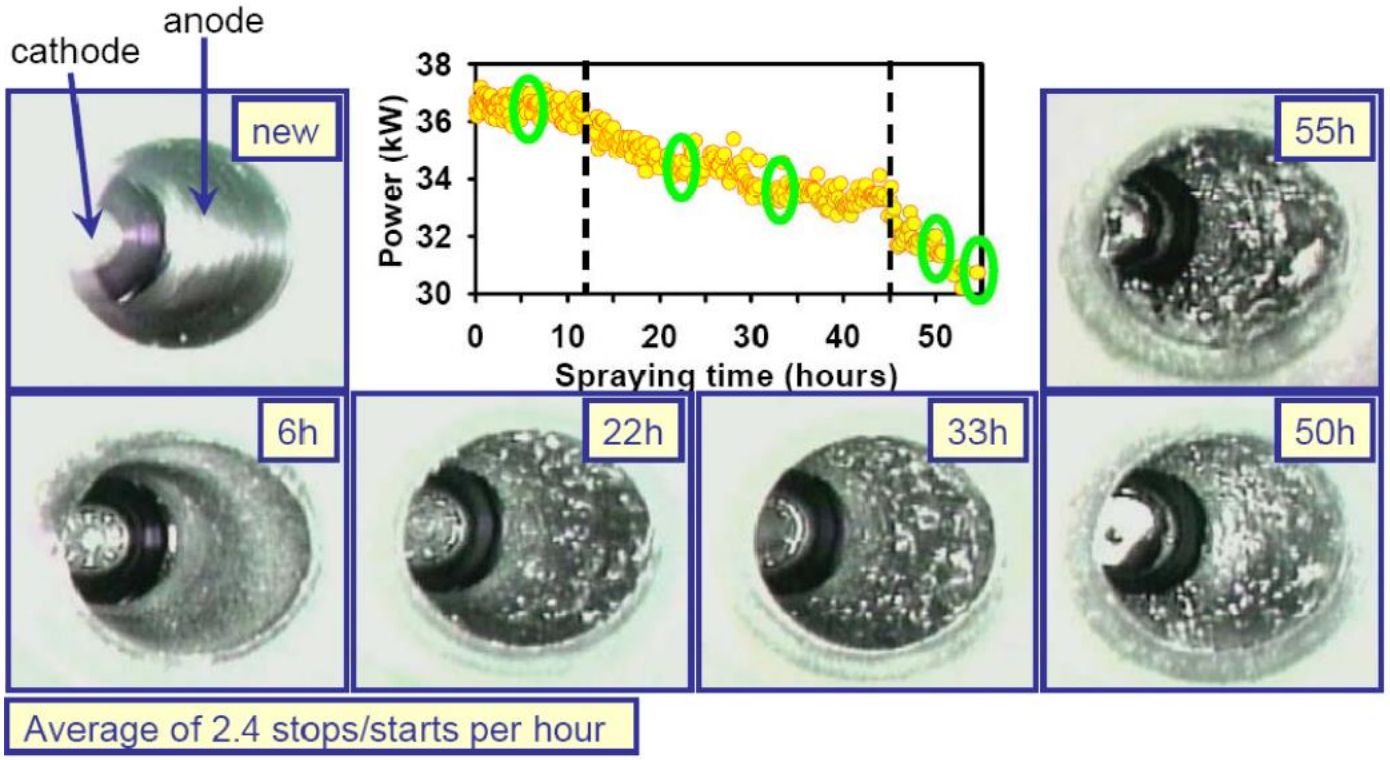
Simply Put

- Select gas combinations
- Select powder delivery and injection systems
- Apply a high DC voltage to
  - Anode or nozzle
  - Cathode or electrode
- Regulate power and current
- Plastifies/Melts and accelerate powder particles

Electrode

Industrial Materials Institute

Electrode Wear

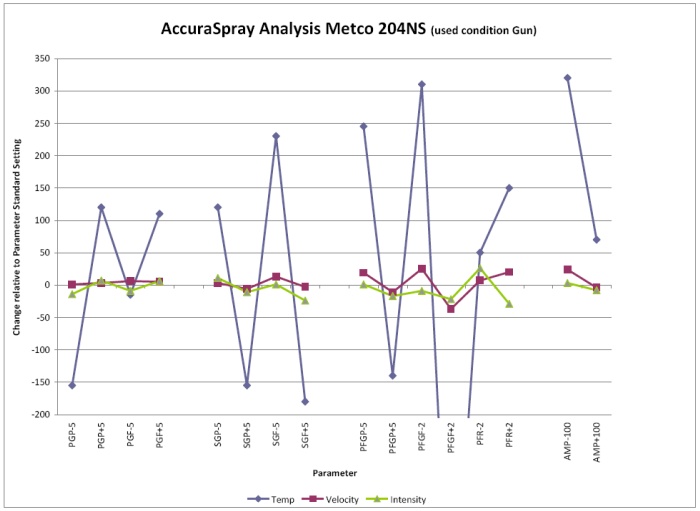


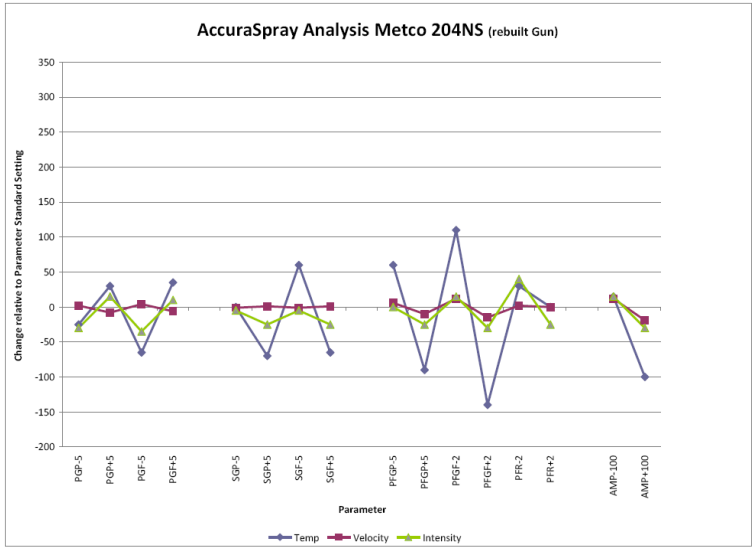
Outline

Process Control

- Temperature control and monitoring
- Placement and calibration of IR
- Types of assisting equipment that can be used in conjunction with spray equipment: such as “Accuraspray”.

Metco 204 Comparison



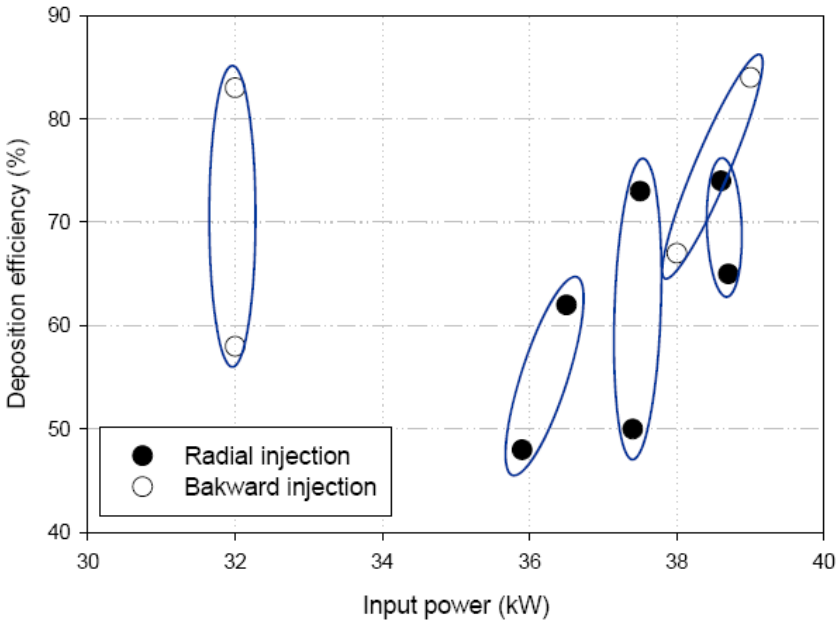


Understand when hardware is worn out!!

Deposition Efficiency vs Input Power

- Coatings are produced using 2 combinations of H_2 flow rate and arc current for each input power level

I (A)	H_2 (l/min)	Input power (kW)	Powder feed port
530	7.1	39	P
560	4.7	39	P
520	7.1	37.5	P
550	2.8	37.5	P
500	4.7	36	P
530	2.8	36	P
530	6.2	38	B
560	2.0	38	B
430	6.2	32	B
475	1.9	32	B



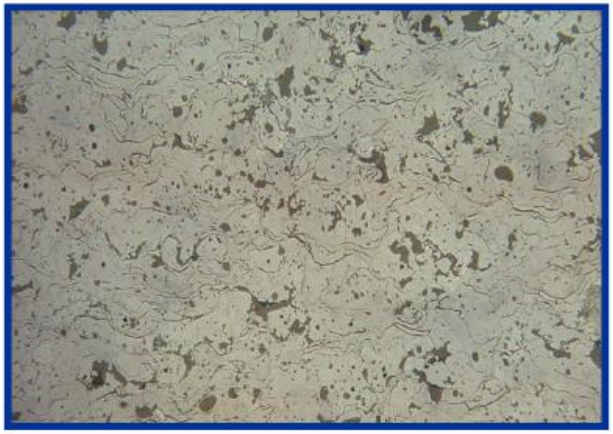
- Bad correlation with input power

Bisson, Dorfman, et al., JTST 2005

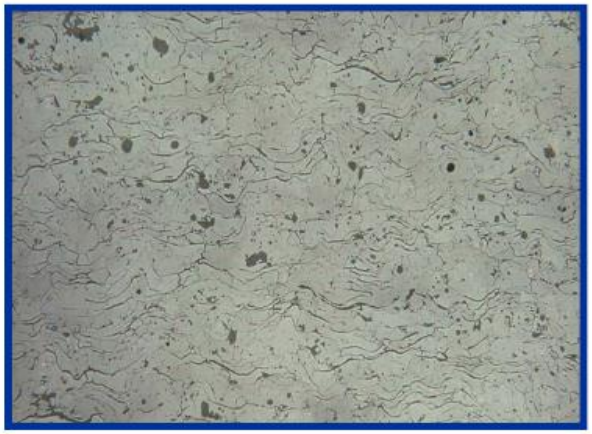
NRC·CNRC
Industrial Materials Institute

Effect of Hydrogen on Coating Structure

- Both coatings produced at 38 kW



Low H_2 level
(2 l/min)
T = 2650°C



High H_2 level
(6.2 l/min)
T = 2840°C

Higher heat transfer to the particles

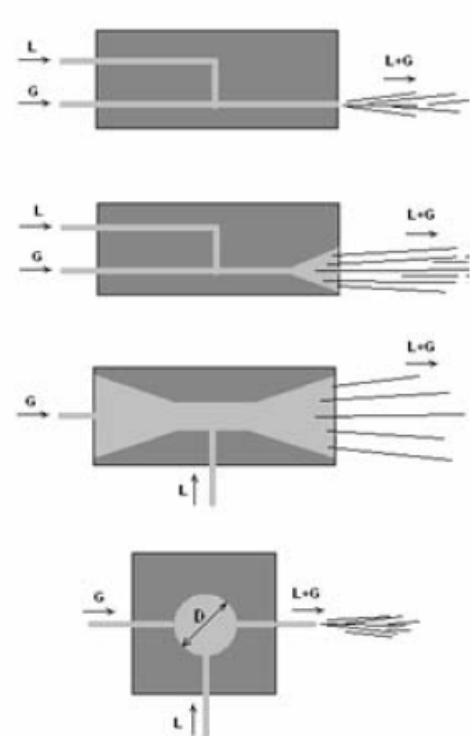
Outline

Cooling

- What type Cooling method is used, (Shop Compressed Air, CO_2, Liquid Nitrogen)?
- Placement of cooling air or system

Control of Cooling Gases-Other

Liquid Nitrogen



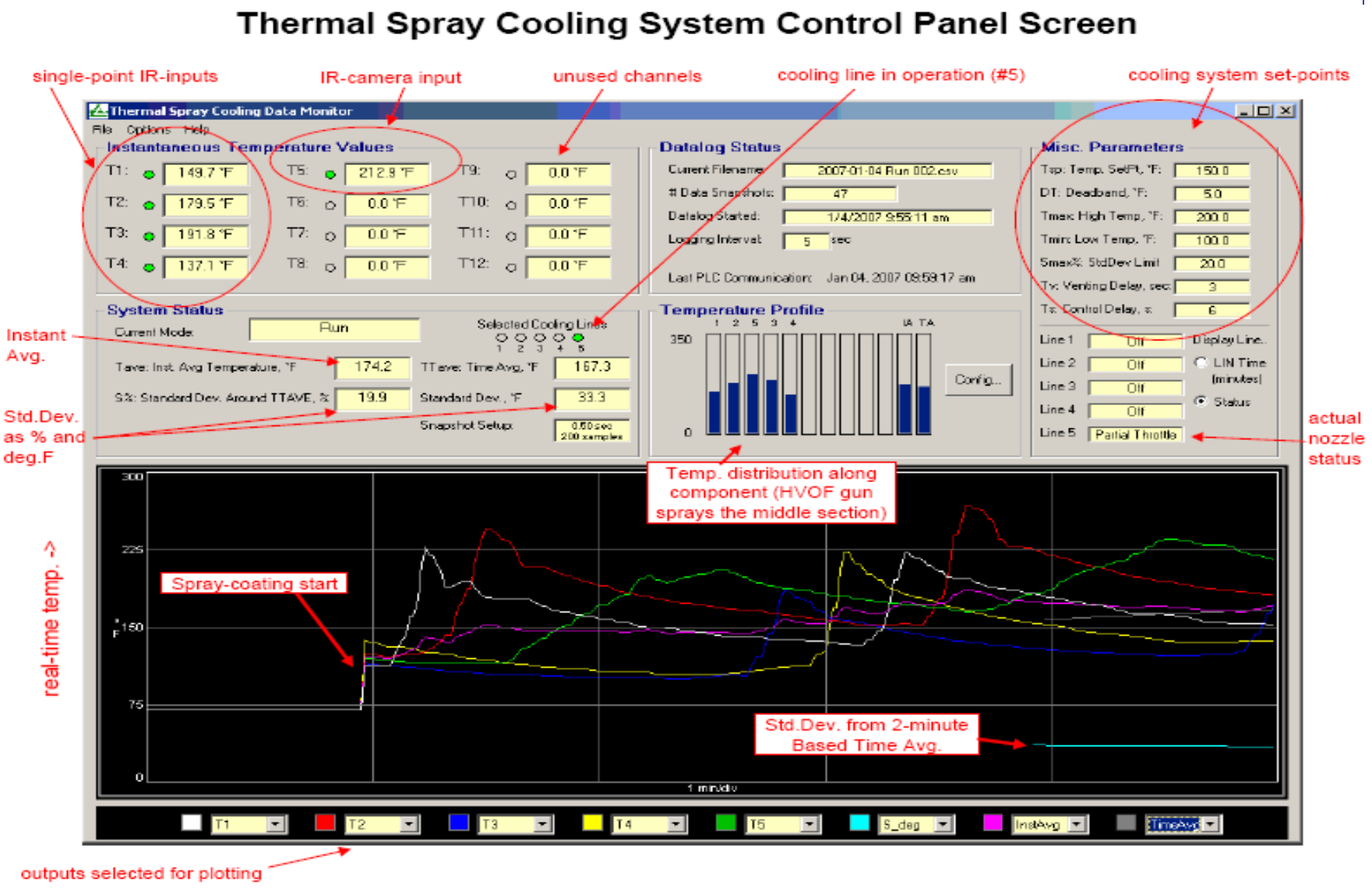
New type of a 2-phase, cryogenic nozzle
- $N_{2(l)}$ flowrate throttled by room-temp. gas, $N_{2(g)}$

4 functions in one nozzle:

- spray atomizing and vaporizing
- proportional flowrate valve
- vapor venting
- coating dust blasting

Cooling lines don't need sub-cooling systems to start fast, only a PLC-control of $N_{2(g)}$

Liquid Nitrogen Cooling



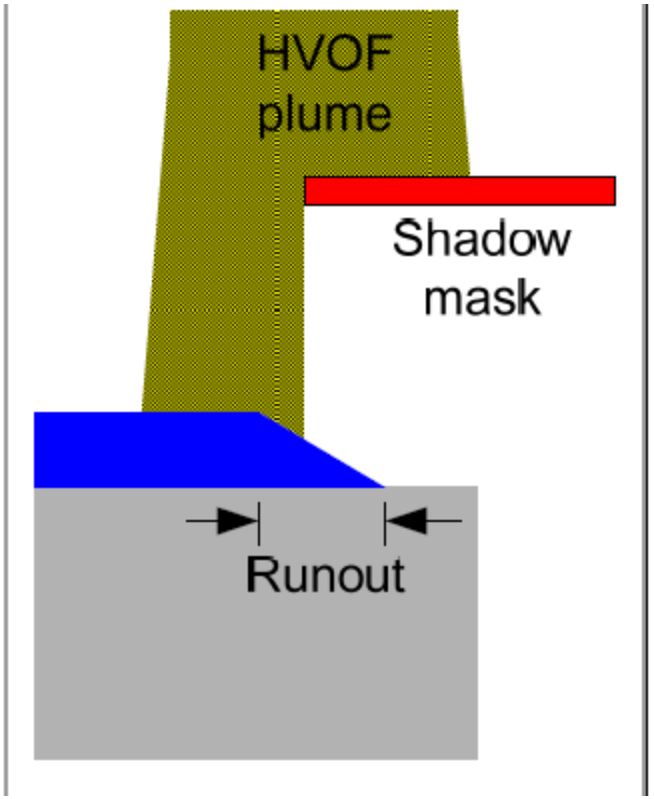
Outline

Masking of Parts

- Tapes/compounds/hard metal/shadow
- Are any Spray Tapes used to mask parts?
- Is Shadow Masking used?
- Is Hard Masking used?
- Is Rubber used?
- Are any Putty Type masks used?
- Current methods
  - Hard Masking (22ga – 11ga Sheet Metal)
  - Tapes
  - Mac-Block
  - Putties

Shadow Masking

- How does shadow masking work!!



Runout

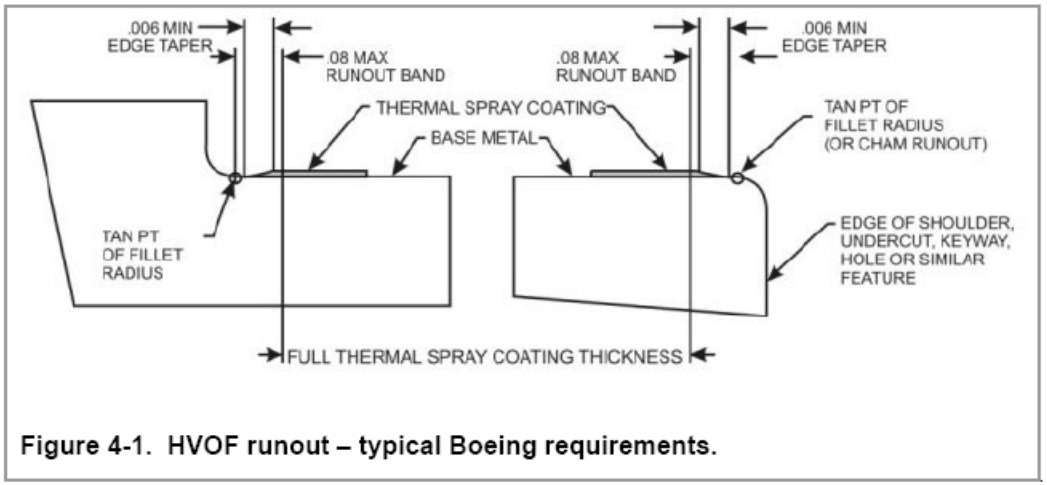


Figure 4-1. HVOF runout – typical Boeing requirements.

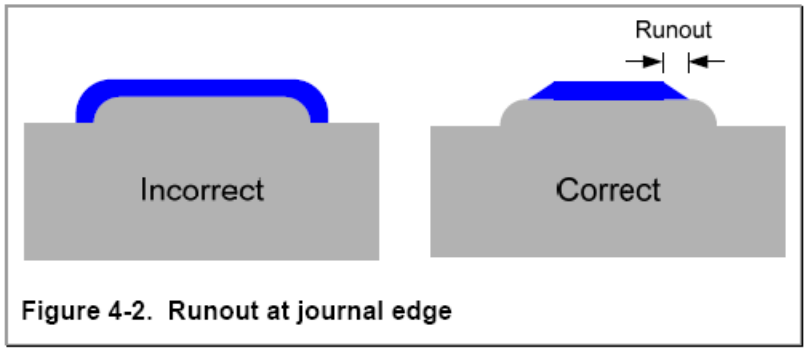


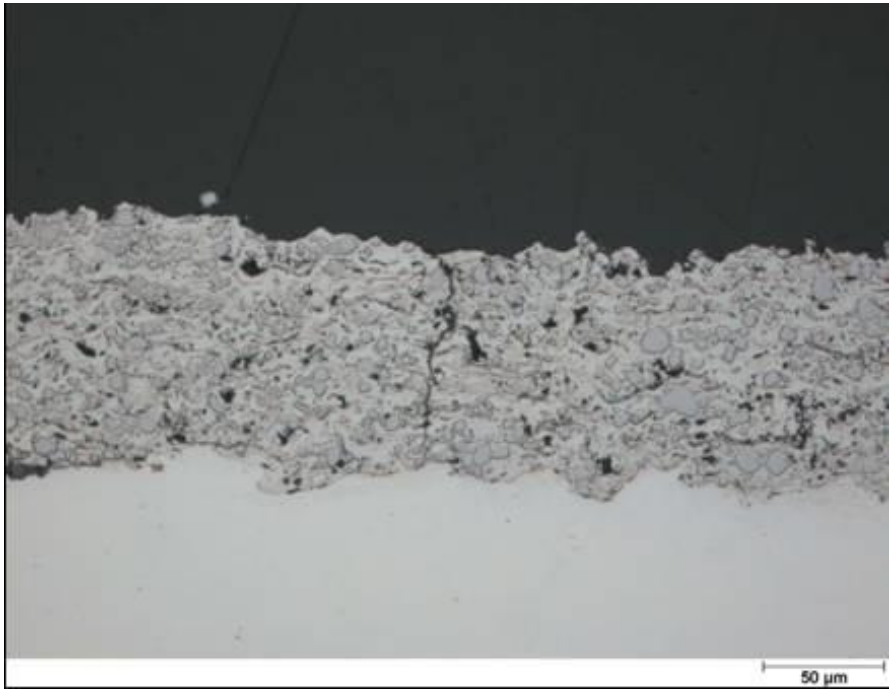
Figure 4-2. Runout at journal edge

Outline

HVOF History and Theory

- Why use HVOF now?
- Why are we using HVOF vs. Plasma?
  - How is it the same?
  - How is it different?
- Critical Issues with HVOF
  - Residual stress
  - Almen
  - Fatigue
- Temperature measurement
- Different types of guns/systems

HVOF vs. Plasma



HVOF vs. Plasma

- Powders
  - Can we use the same powders for HVOF vs. Plasma??

HVOF vs. Plasma

- If plasma powder has distribution from beach balls to marbles, how will we be able to make the beach balls go fast enough in HVOF??
- Need to cut off the high and low end of the powder distribution to get the same powder to work in HVOF systems

Outline

Spray Booths

- What type of manipulation equipment is used, (Robot or Gantry)?
  - Turntable and traverse speed calculations
  - Degrees of freedom on robot
- Make-up air and flow
- What type of dust collectors are used?
- Are temperature measuring devices used, (Manufacturer and Model)?

Air Flow

- What is Air Flow?

- Why is Air Flow important?

Air Flow

- Air Flow is the movement of incoming supply air to the booth which is then exhausted. It is measured in SCFH (Standard Cubic Feet per Hour)
- It can also be determined by an exchange rate – how many times all the air in the booth is evacuated and fresh air replenished
- Here is an example to calculate the exchange rate
- Booth Size – 10’x10’x10’ = 1000 sq feet
- Exhaust SCFH = 3500
- 3500/1000 = 3.5 times per minute

Air Flow

- Many people do not understand that Air Flow through the booth helps to cool the part being coated if it is in the right position to take advantage of the air flow path
- Air Flow can also effect your spray pattern if it is in the direct path of the guns plume causing poor deposit efficiencies and possibly poor coating quality
- Many times there are dead spots in the air flow causing issues especially with bigger parts

Outline

Spray Equipment

- What type equipment is being used?
  - Type of console
- Gun type?
  - Special parts caps, etc
- Feeder Type?
  - Special parts hoses, etc

Hands-on

System Maintenance

- HVOF Gun
- HVOF Gun Console
- Powder Feeder
- Rebuilding of gun and when to rebuild
- Rebuilding of Powder Feeder Hopper and when to rebuild
- Varied equipment/system issues that can arise
- Powder feeder issues
- Gun and Feeder Hoses and Cables
- Spark Igniter and Flame Out Detector

Outline

Parts that are Sprayed

- What types of parts are being sprayed?
- What are the substrates of the parts?
- What size are the parts?
- What is the geometry of the parts, (round, flat, complex shapes)?
- Do these parts hold a lot of heat?
- How are parts prepped for spray, (cleaning, masking, grit blasting)?

Hands-on

Demonstration using equipment to show

- Troubleshooting console
- Troubleshooting and rebuilding of gun
- Troubleshooting and rebuilding of powder feeder
- With a generic part, how to:
  - Clean
  - Grit blast
  - Mask
- Spraying generic part and test samples with cooling set-up

Hands-on

Part Processing Hands-on

- A proto-type part should be used during the training as a guide to demo the process of qualifying a product part using the Plasma/HVOF process.
- Use of actual dummy parts
- Grit blasting of part and coupon
- Part and coupon sample preparation
- Masking Techniques - Hard Masking, Tapes and other types of masking material that could be used.
- De-masking techniques
- Trail runs and set-ups with coupon preparation, spray, temp measurement, Almen and all lab evaluation

SE Tentative/Possible
Training TOPICS

1	Training Outline
2	Thermal Spray (TS) Background
3	Clean-Grit Blast
4	Plasma Theory
5	HVOF General/Specific
6	Powders
7	Consoles
8	Masking Cooling Fixturing
10	Process Control Plume Sensor and Metallography/Testing etc.
11	Plasma System/Gun-Lessons Learned
12	HVOF System/Gun-Lessons Learned
13	Other Processes-Lessons Learned
14	Maintenance
15	Technical Papers

Hands-on

A	Booth and Plume Sensor-Changing Parameters Plasma, HVOF, other processes as required
B	Testing-Tensile Testing, Metallography, etc.
C	Grit blasting, Masking, and Cooling
D	Hopper/Gun Rebuilds