Online monitoring of cold spray for solving challenges in industrial adaptation

Cold Spray Club, Munich 2024-10-18

Jussi Larjo, Oseir Ltd.

HiWatch line

Oseir

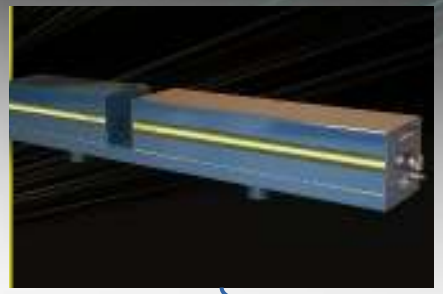
HW Compact

HW

2002

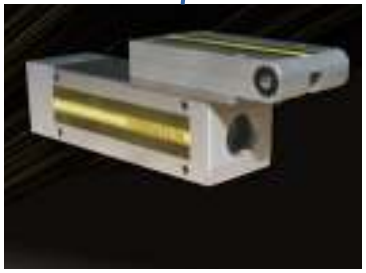
2005

HiWatch HR



2011

HiWatch CS



HiWatch CS2

2015

ShotWatch

2017

2018

HiWatch CS-Q

2019

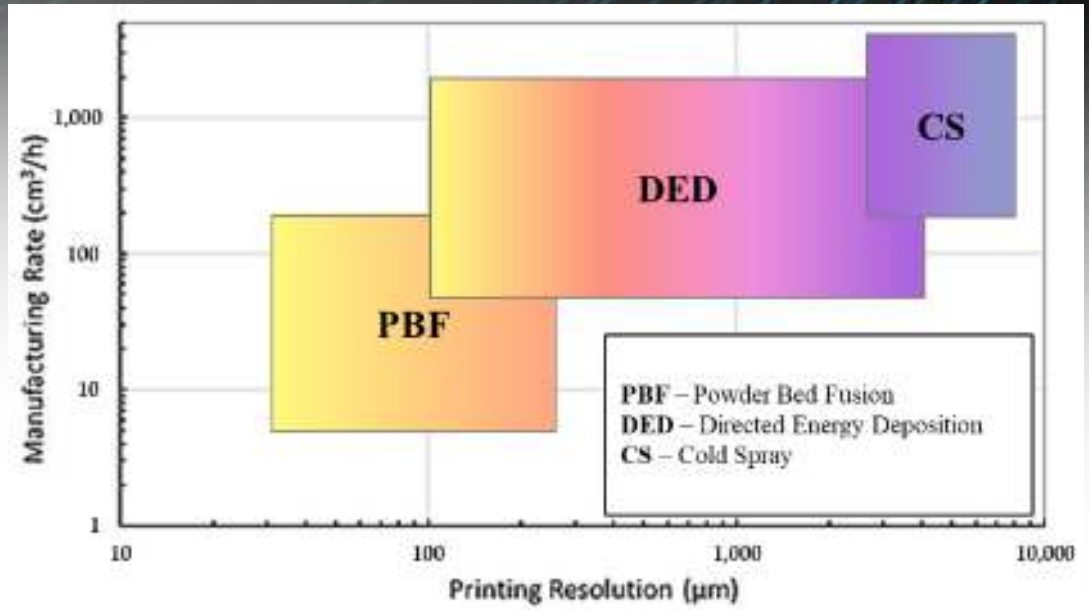
HiWatch HR2

2024

Cold Spray Additive Manufacturing

Oseir

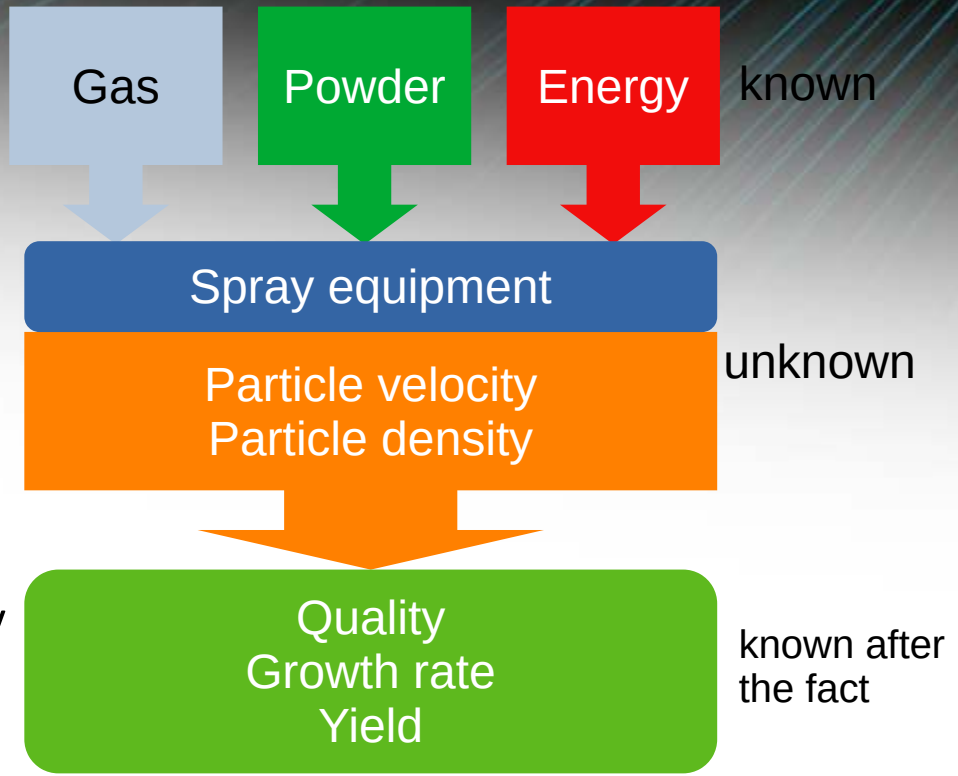
- Rapidly emerging technology
  - Aerospace
  - Defence
  - Automotive
  - Manufacturing



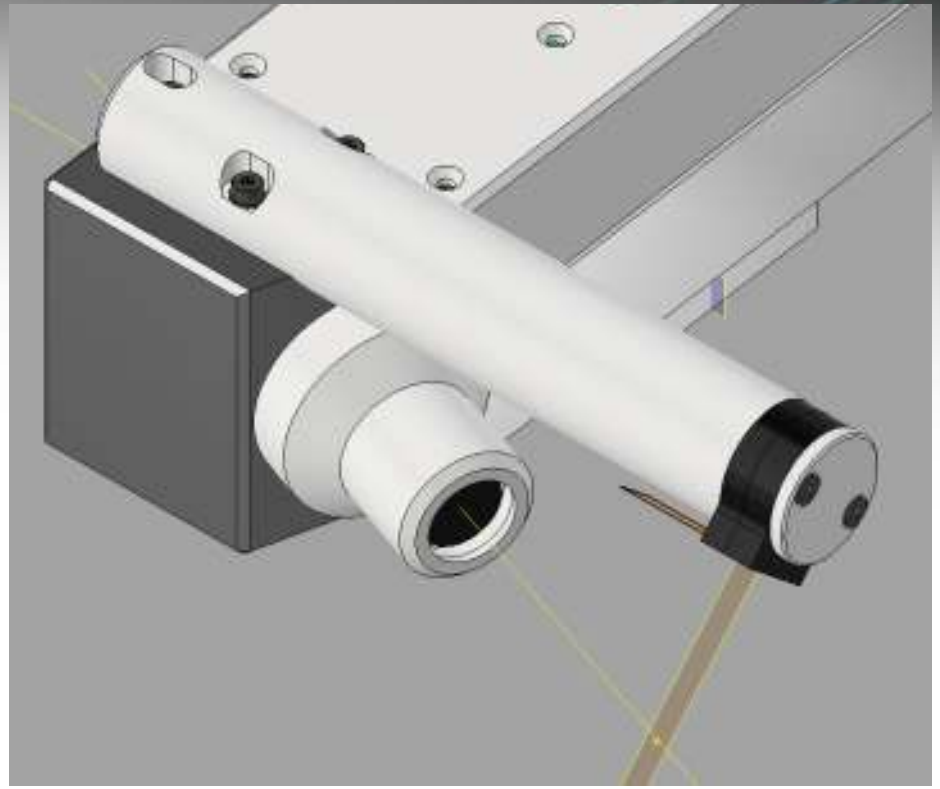
Ralls, A.M. *et al*. Materials 2023, 16, 2765
after Zou, Y. Acc. Mater. Res. 2021, 2, 1071–1081

Online monitoring: spray failures

- Feedstock
  - agglomeration
- Equipment wear
  - Nozzle, injector port, feed line
- Gun degradation
  - clogging
- System malfunction
  - Powder feeder
- Operator issues
  - Setup failures
- Affect particle propeties instantly

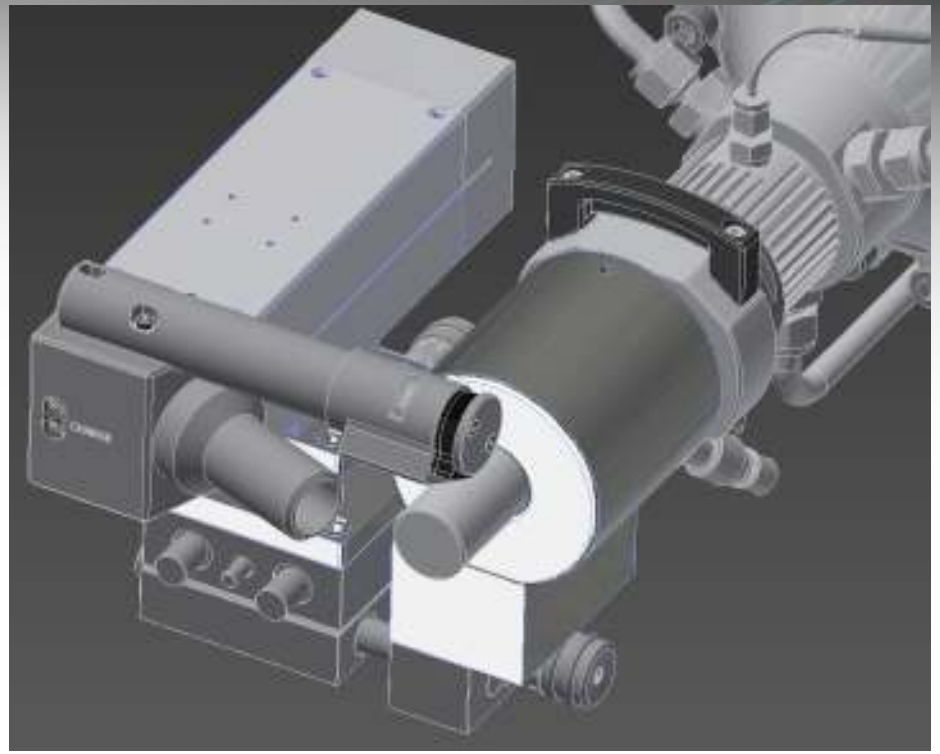


Continuous online sensor: HiWatch CS-Q



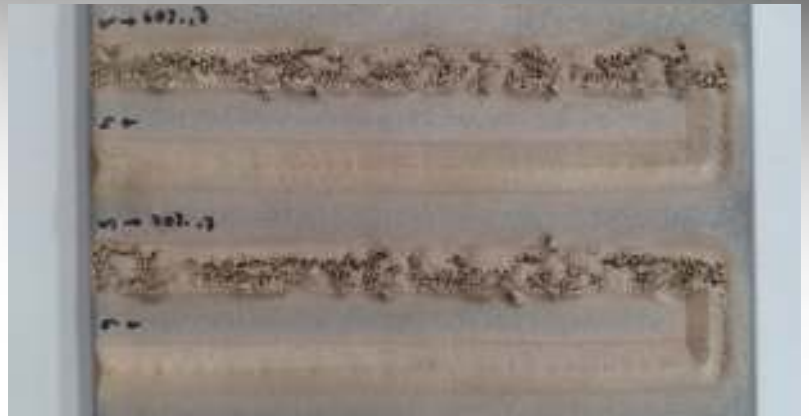
- Sheet illumination
  - Operation and features like HiWatch CS2
  - Measurement area ~7x6mm^2
  - 1.6MP, 45fps (GigE)
- Imaging geometry
  - Camera view: 20° angle
  - Laser sheet: 45° angle
  - Parallel mounting with spray nozzle

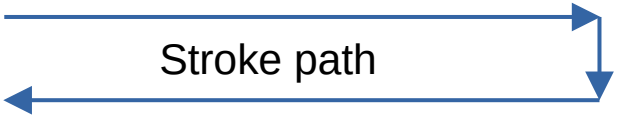
Mounting HiWatch CS-Q



- Mount structure to Impact 5/11 spray gun
- Position adjustments +/-12,5mm
- Combined weight < 5kg
- Connects to nozzle cooling jacket
- Clearances
  - Spraying standoff > 30mm
  - Measurement zone 15-20mm from nozzle exit

Case: Plume asymmetry effect (a)



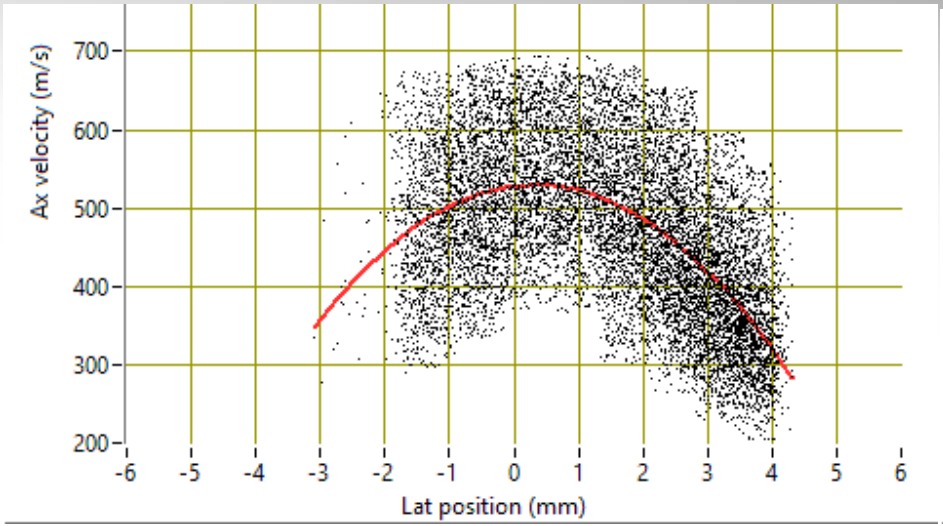


- Bronze powder
  - Single pass scans on test coupon
  - Right stroke: strong flaking artifacts
  - Left stroke: expected result
- Plume asymmetry suspected

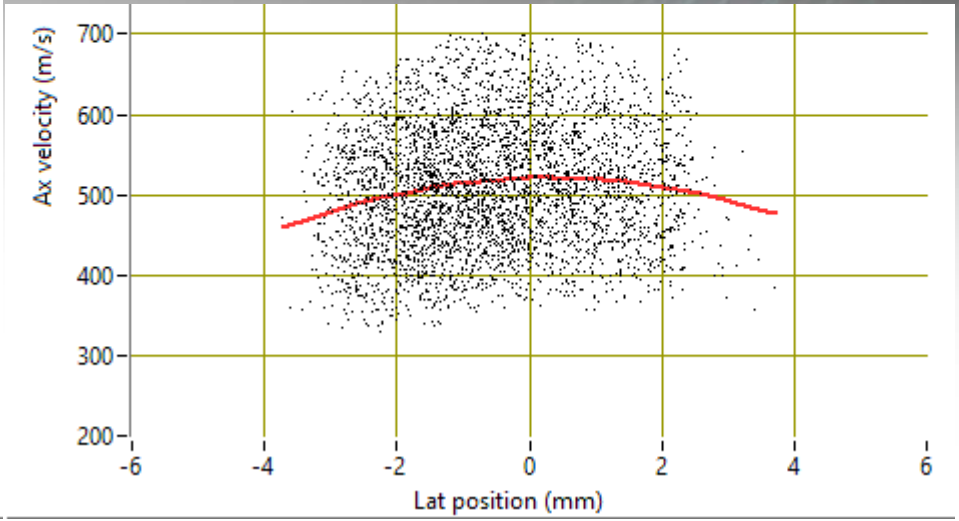
Case: Plume asymmetry effect (a)

Feed rate and carrier gas flow adjustment

Original feed



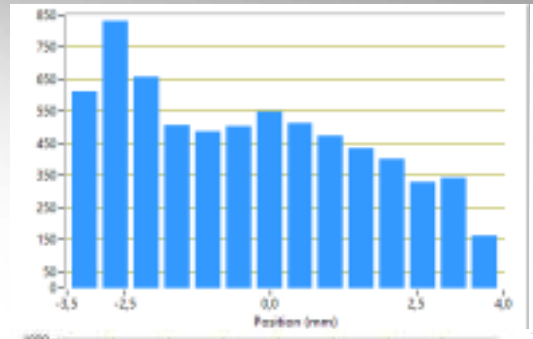
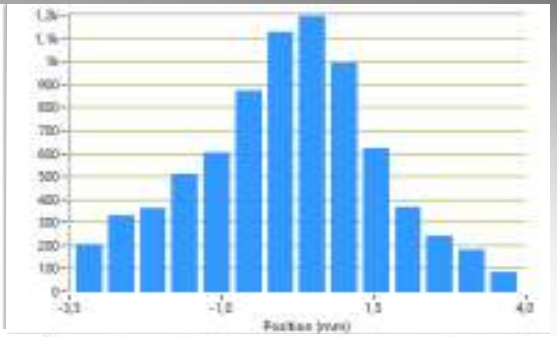
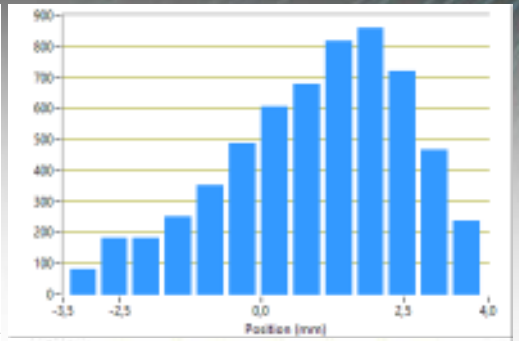
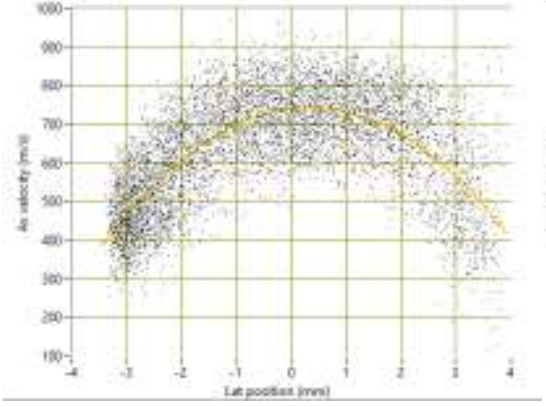
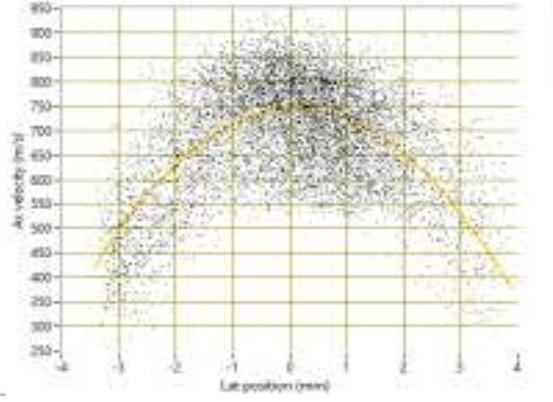
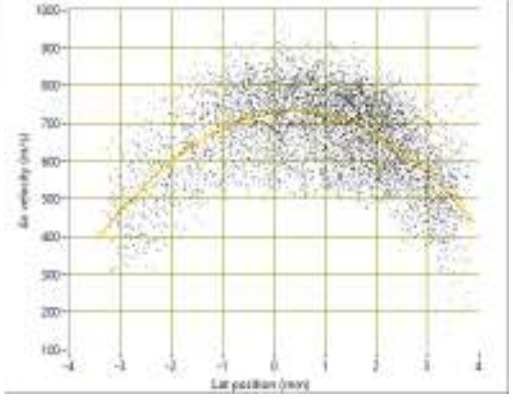
Adjusted feed



Case: Plume asymmetry effect (b)

Centerline spray gun: Venturi based feed mechanism

- Gun pressure affects feed flow

	Low p	Med p	High p
Density distribution			
Lateral v distribution			

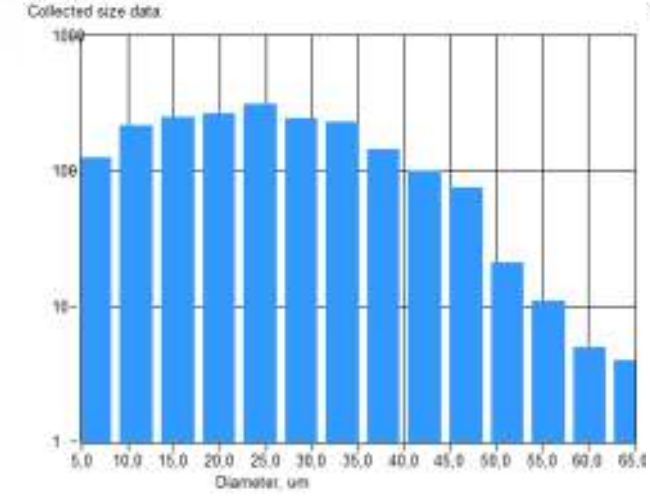
Case: Powder QA

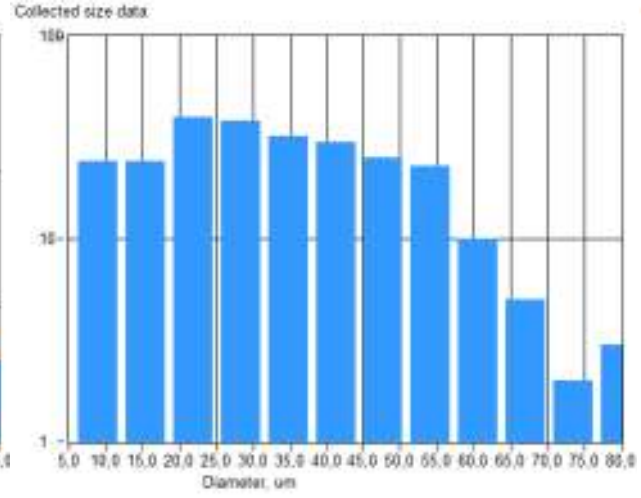
HR2 spray experiment of the same powder stock, identical process parameters

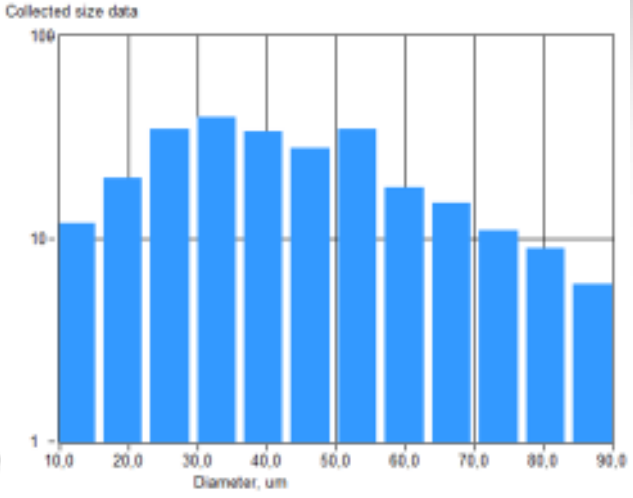
Feb 2019:
D50 25 µm
Mean velocity: 665 m/s
Plume density: 69

Mar 2019:
D50 33 µm
Mean velocity: 617 m/s
Plume density: 29

Jun 2019:
D50 64 µm
Mean velocity: 605 m/s
Plume density: 27

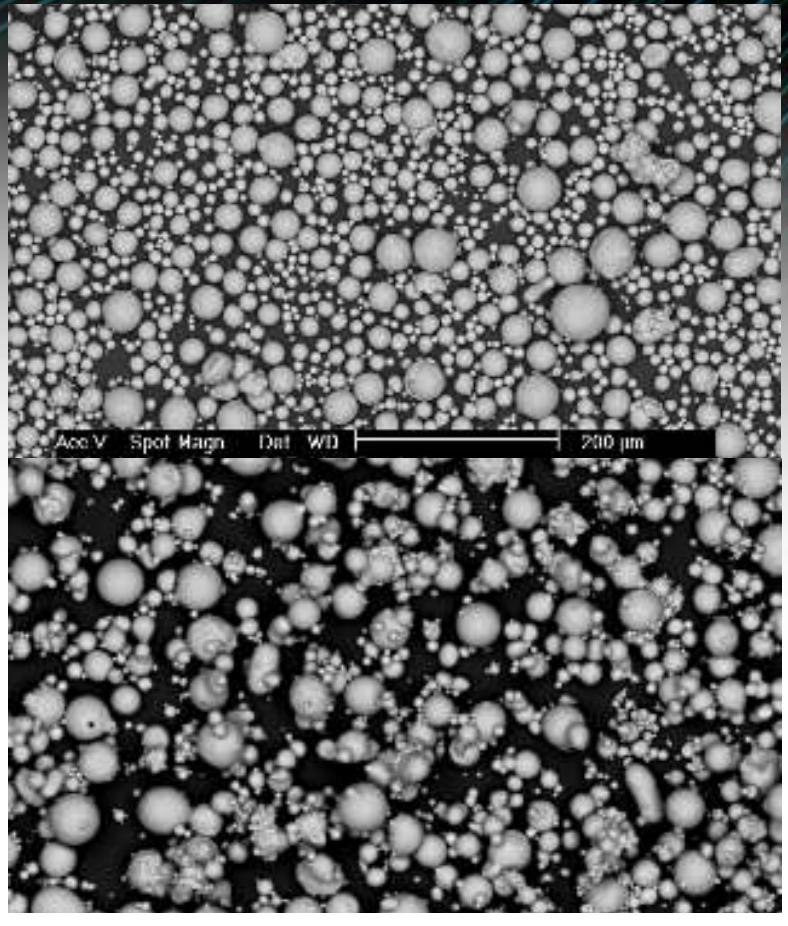






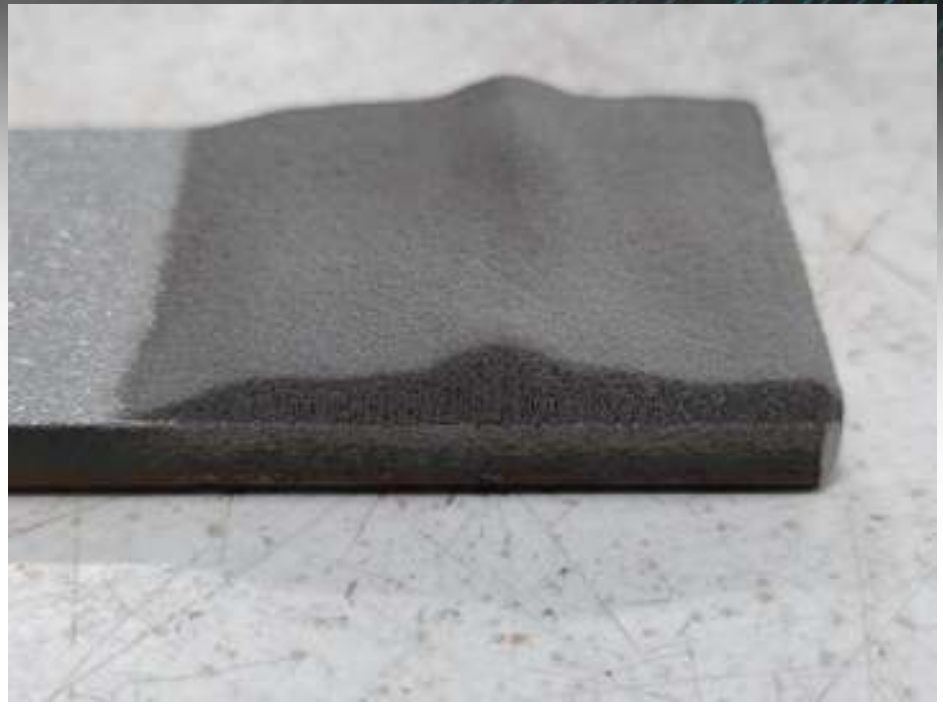
Case: Powder QA

- Comparing SEM images of powders
  - agglomerates present after long storage
  - HR2 data suggests rapid change during one month
  - Coating yield 70% lower in latest deposition tests
- Periodic powder testing needed during long storage



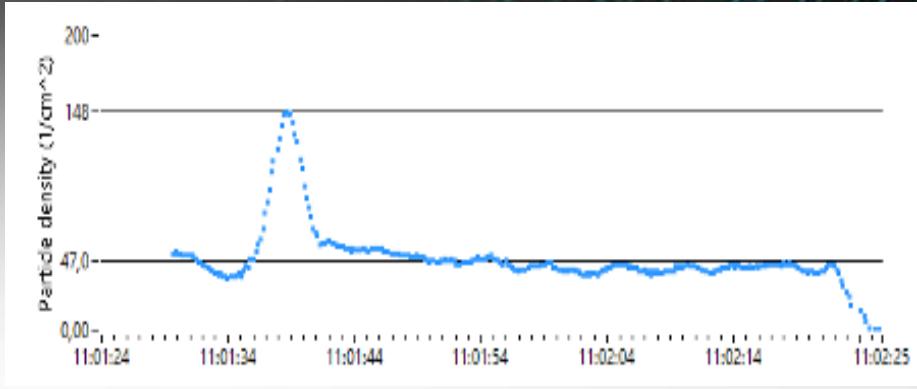
Case: Feed stability

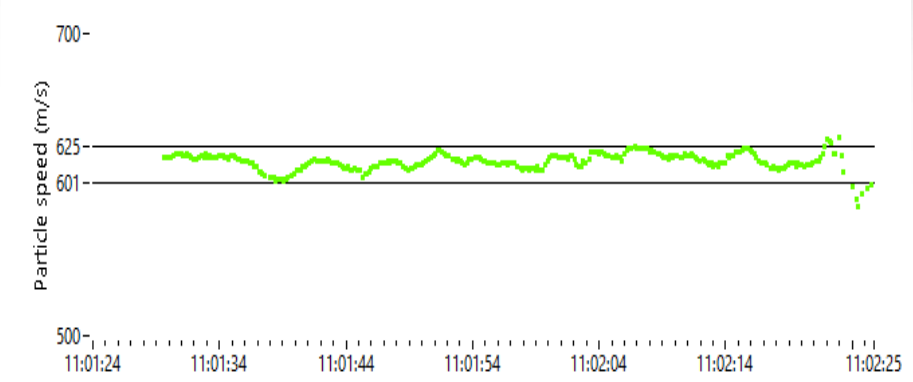
- Repeat tests with pure Ti powder
  - Variable standoffs
  - 4 passes
  - Duration 50 s
- Anomaly in coating thickness
  - In single sample only



Case: Feed stability

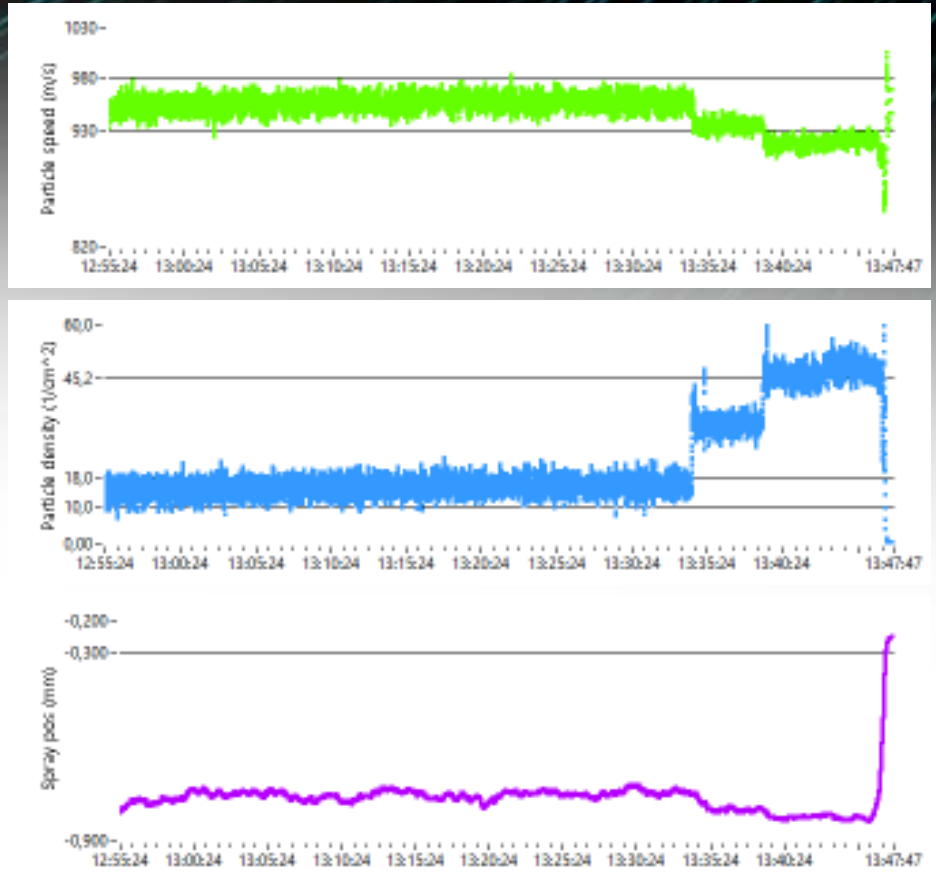
- CS-Q Sensor data
  - Density: large peak seen in middle of first layer
  - Matches the position of the ridge
  - Speed almost unchanged
  - Likely feeder/feed line issue





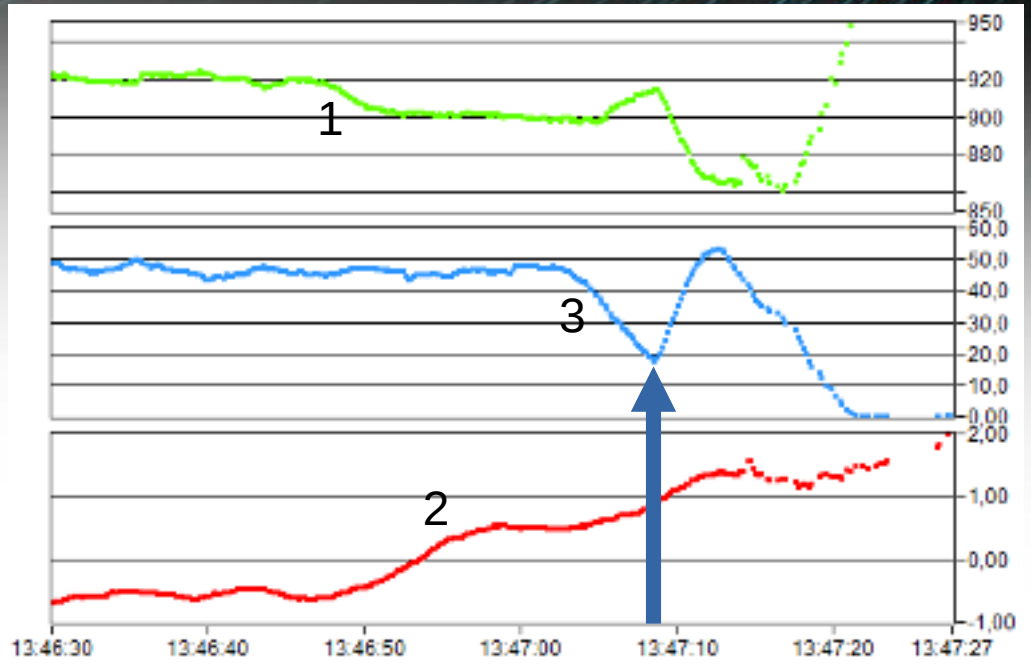
Case: Clogging prediction

- CS-Q w/ Impact 5/11
  - Long duration Inconel 635 spray
  - Standoff 45mm
  - Measuring dist 17mm
  - Feed increased twice to incite clogging
- Clogging event at ~13:47

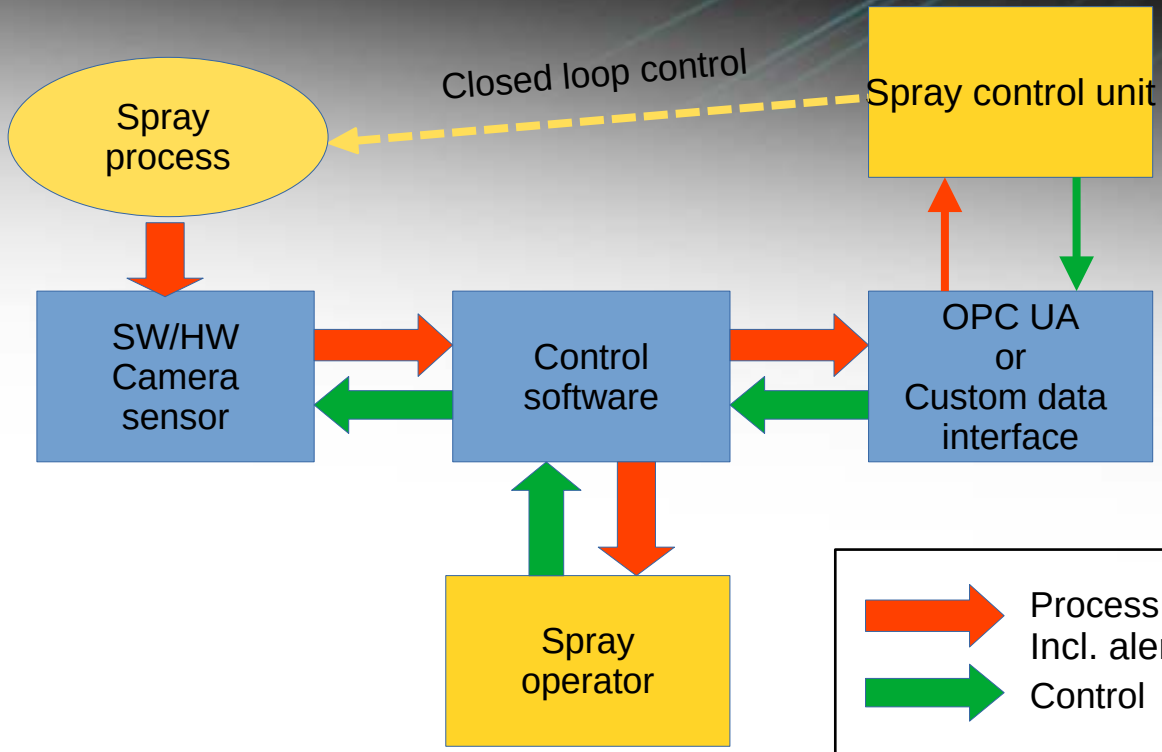


Case: Clogging prediction

- Events before clog discharge
  1) 20m/s speed drop
  2) 1mm change in position
  3) Sudden drop in density
- Discharge at 13:47:09
  - ~10s grace period from sensor level alert
  - alert on speed and position



Closed loop operation



Closed loop control adjusts spray operating parameters according to particle data provided by the sensor

Conclusions

- HiWatch CS-Q sensor
  - Mounts on spray gun for robot controlled CS operation
  - Offers continuous particle data stream during process
  - Can detect multiple issues in spray process:
    - Asymmetric powder feed
    - Powder quality changes
    - Powder feed instability
    - Nozzle clogging
  - Allows real time response to issues
    - Least time/material loss, scrap

Thank you!

Acknowledgements:
TAU:
- Heli Koivuluoto
- Jarkko Lehti
- Anssi Metsähonkala

Impact Innovations:
- Sebastian Pichlmeier
- Severin Noll

Available 2024