U.S. ARMY RDECOM® TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

U.S. Army Research, Development and Engineering Command

Cold Spray Systems Capabilities

ARL

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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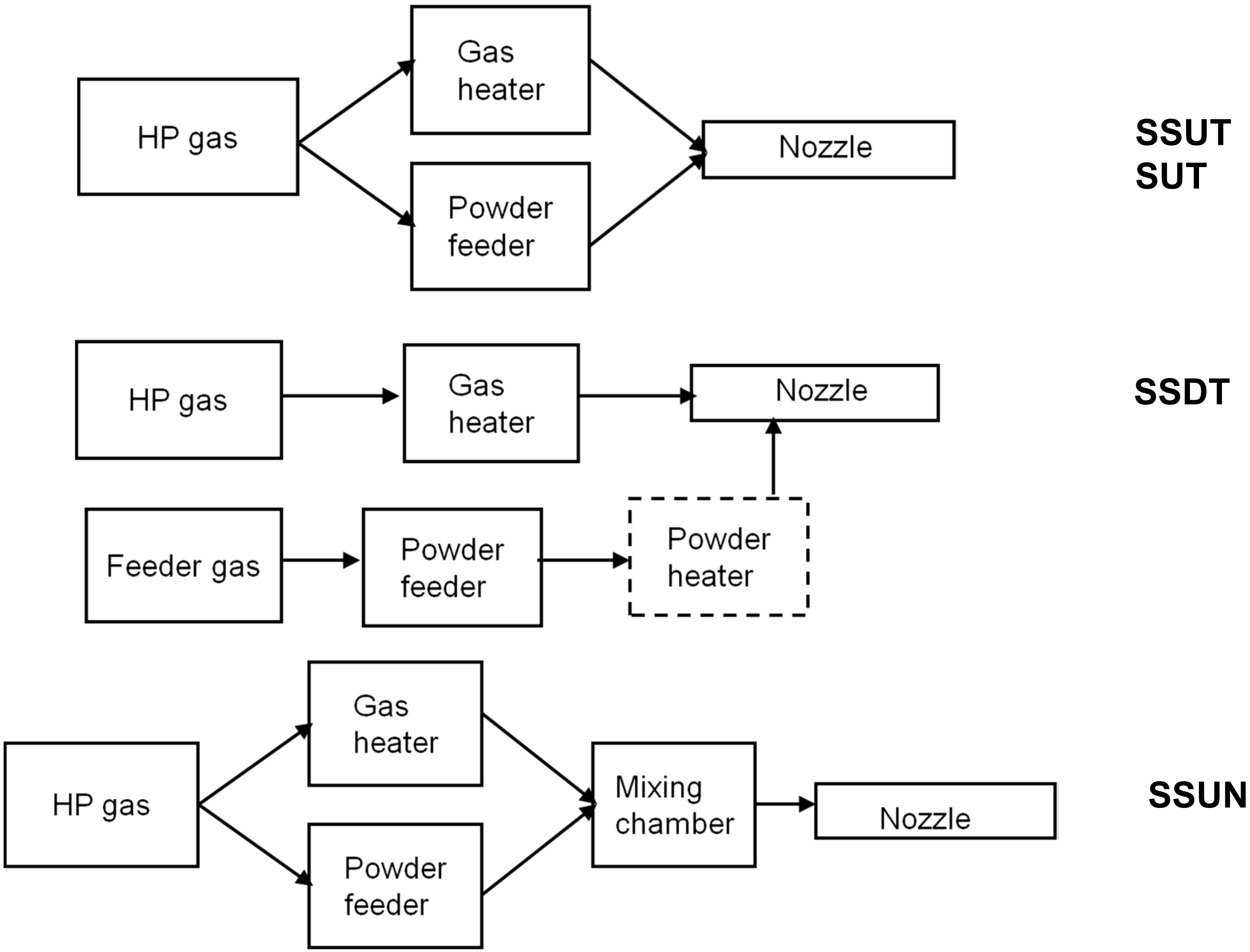
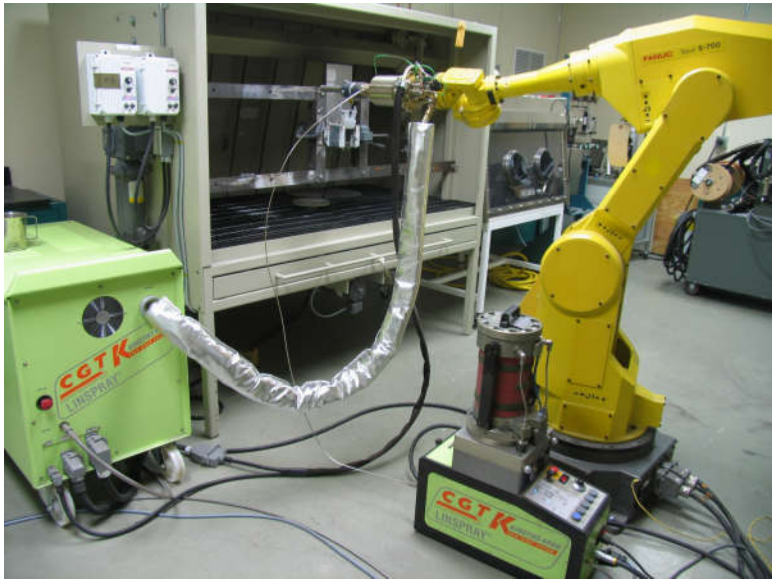
System Categories

- Supersonic nozzle, powder introduced upstream of throat (SSUT)
  CGT, Plasma Giken, Impact
- Supersonic nozzle, powder introduced downstream of throat (SSDT)
  Centerline, Russ Sonic
- Sonic nozzle, powder introduced upstream of throat (SUT)
  Inovati
- Supersonic nozzle, powder introduced upstream of nozzle (SSUN)
  VRC

System Arrangements



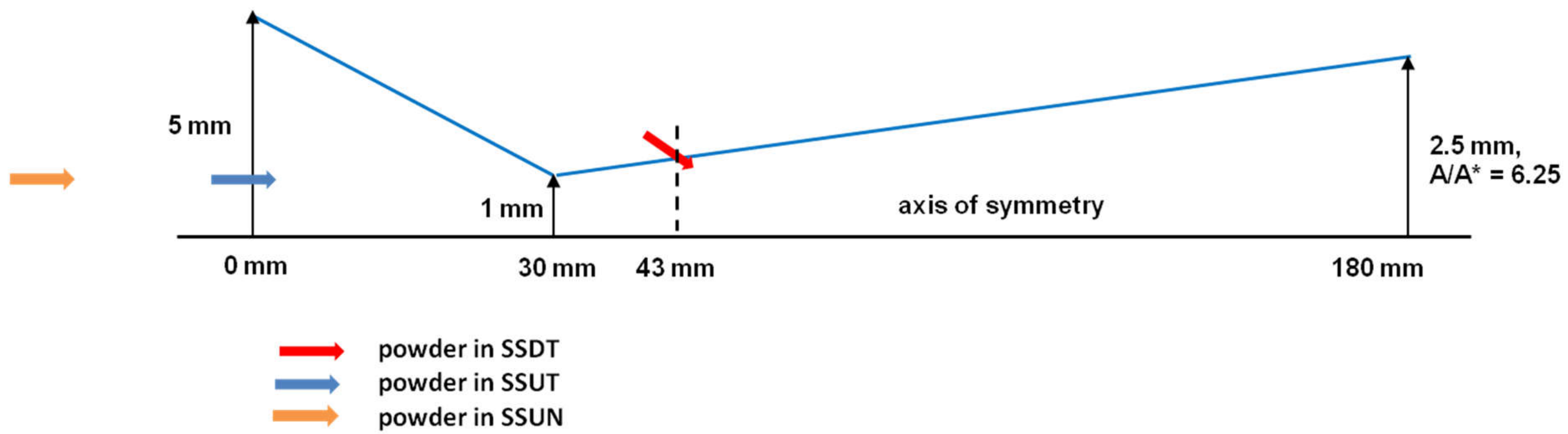
Cold Spray Systems SSUT and SUT

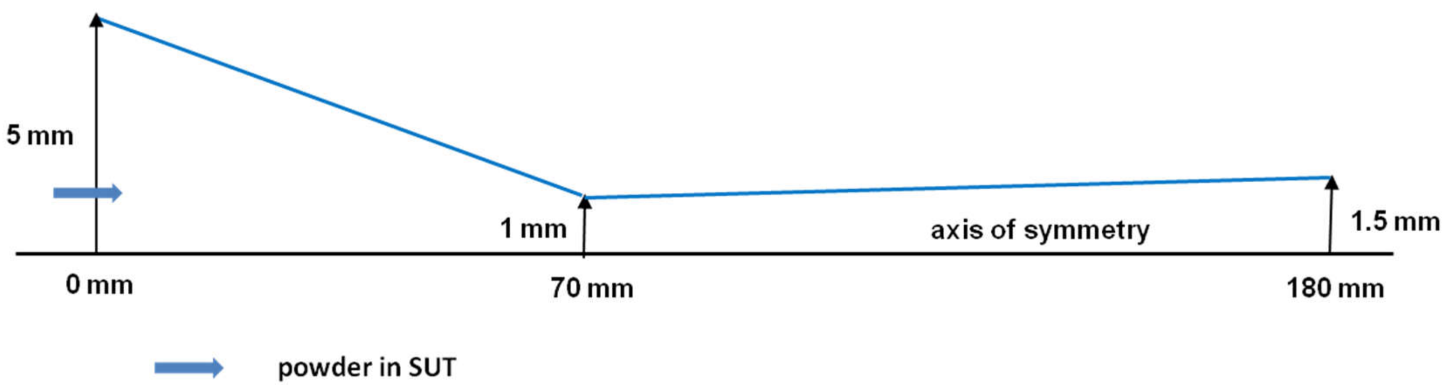


Cold Spray Systems SSDT

Cold Spray Systems SSUN

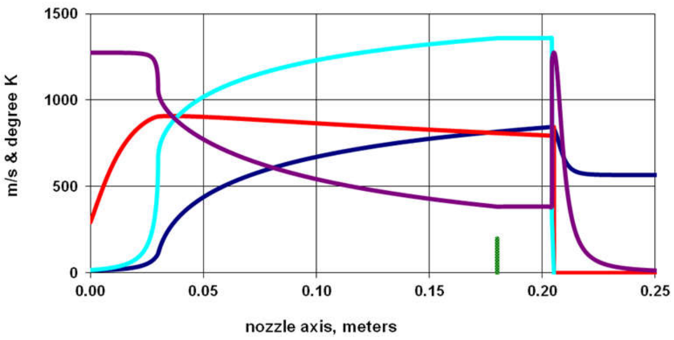
Generic Nozzles



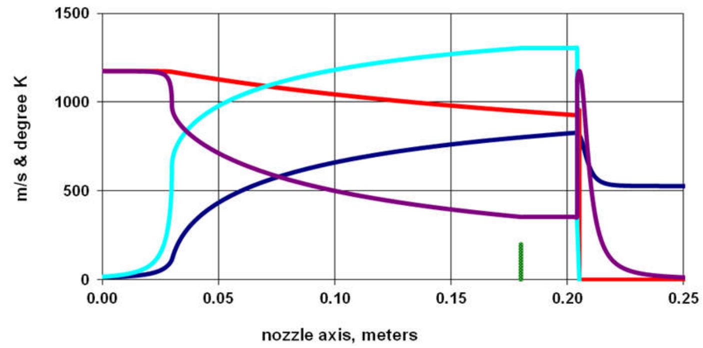


Nozzle Performances for Nitrogen
20 micron, spherical, copper particles

SSUT

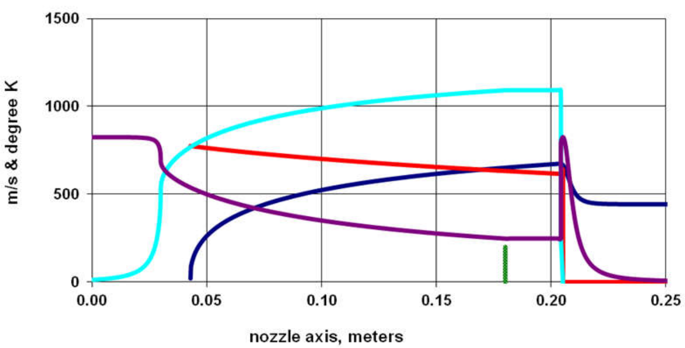


SSUN

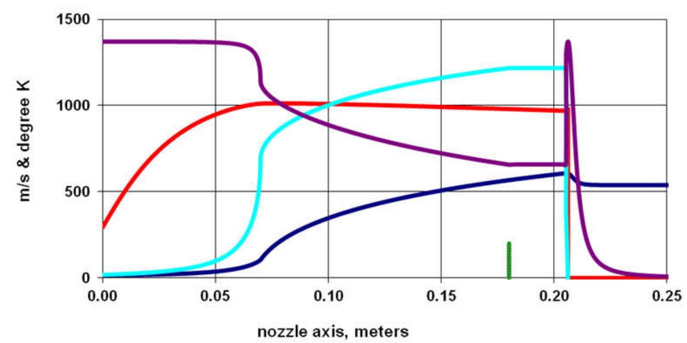


SSDT

(Particles heated to 500 C prior to injection)



SUT



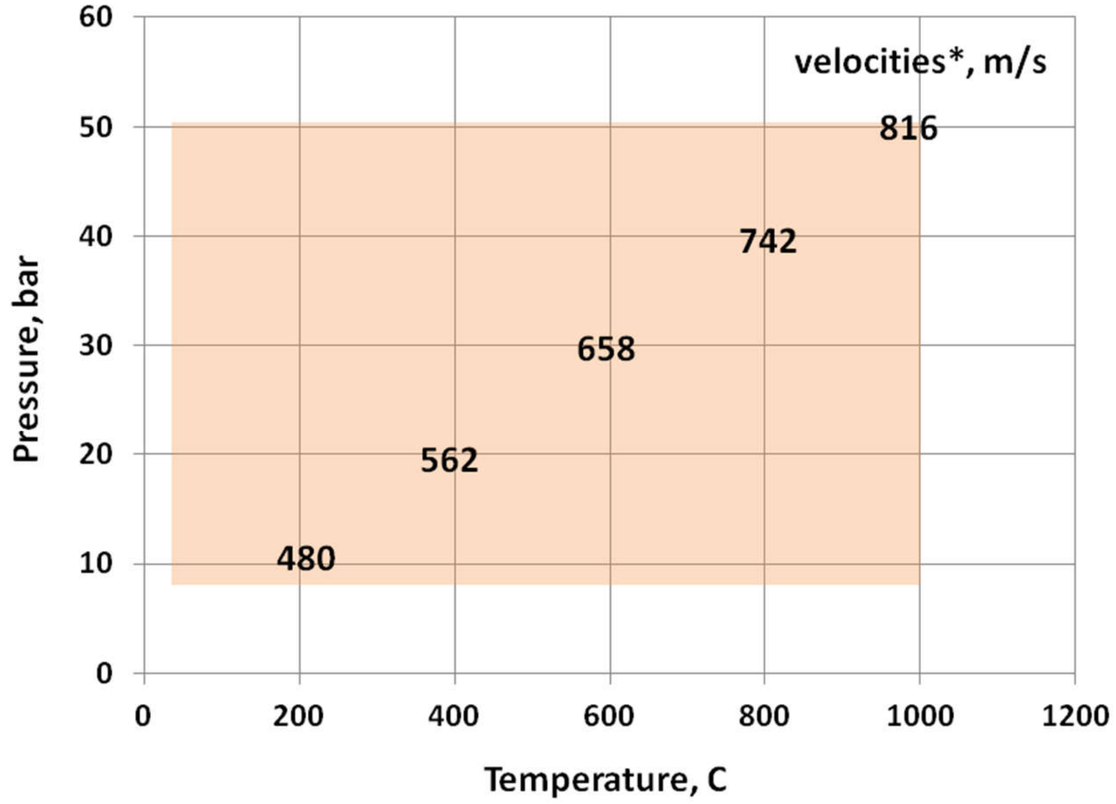
particle velocity | particle temp | nozzle exit | gas velocity | gas temp

Operating Parameters

	SSUT	SSDT	SSUN	SUT
Max Gas Pressure, bar (psi)	50 (725)	35 (500)	55 (800)	9 (130)
Max Gas Temperature, C	1000	550	900	1100
Throat Diameter, mm	3.0	2.5	2.0	1.6
N_2 Flow at Max Conditions, NCMH (sonic throat)	113	68	58	6
He Flow at Max Conditions, NCMH (sonic throat)	319	193	163	16
Particle Exit Velocity*, m/s, N_2 (He) (generic nozzle)	816 (1291)	650 (1014)	803 (1289)	568 (860)
Particle Exit Temperature*, C, N_2 (He) (generic nozzle)	536 (480)	46 (-6) 358(224)**	675 (415)	706 (783)

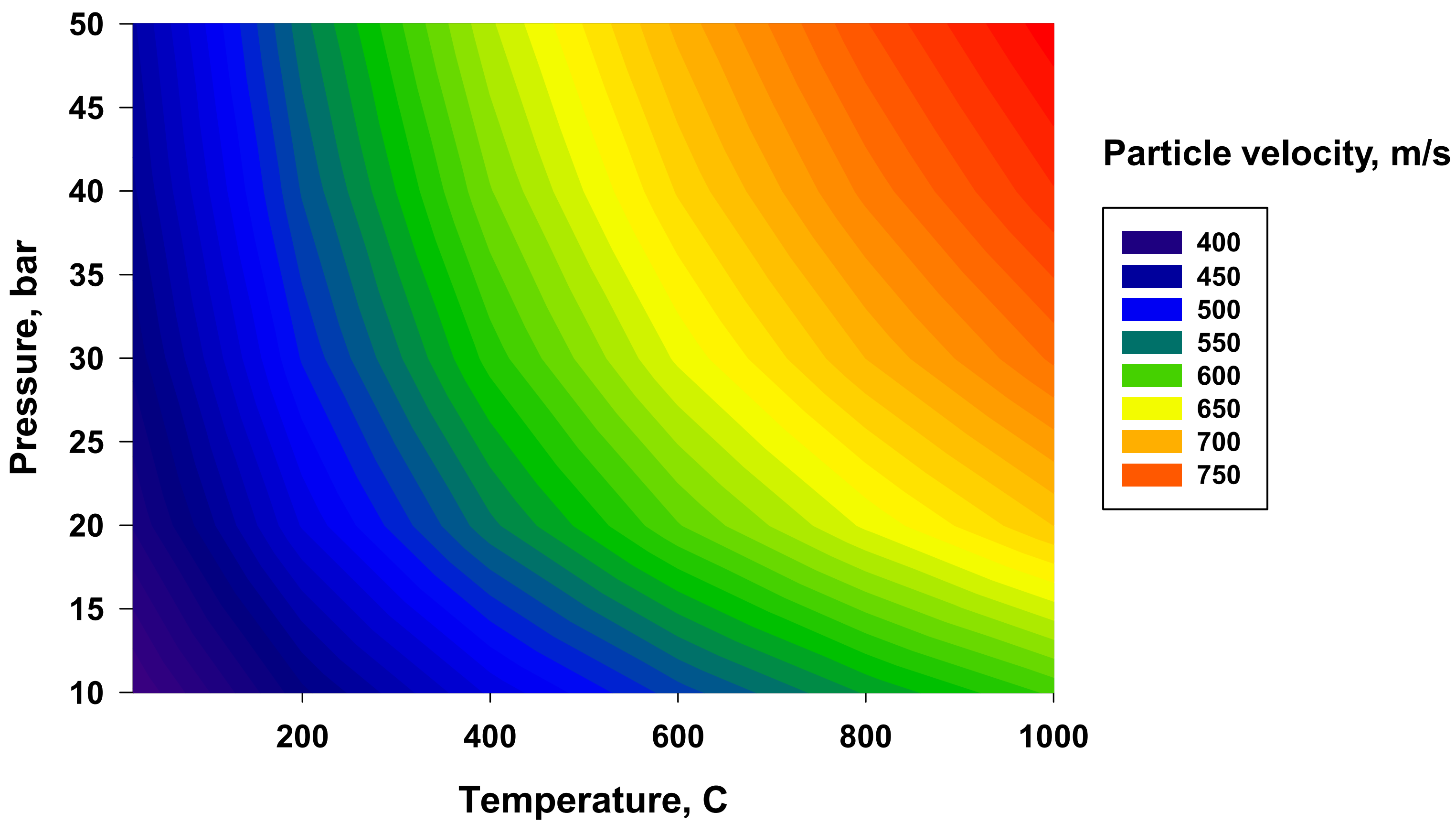
* 20 micron diameter, spherical, copper particle
** Particles heated to 500 C prior to injection

Overall Operating Range



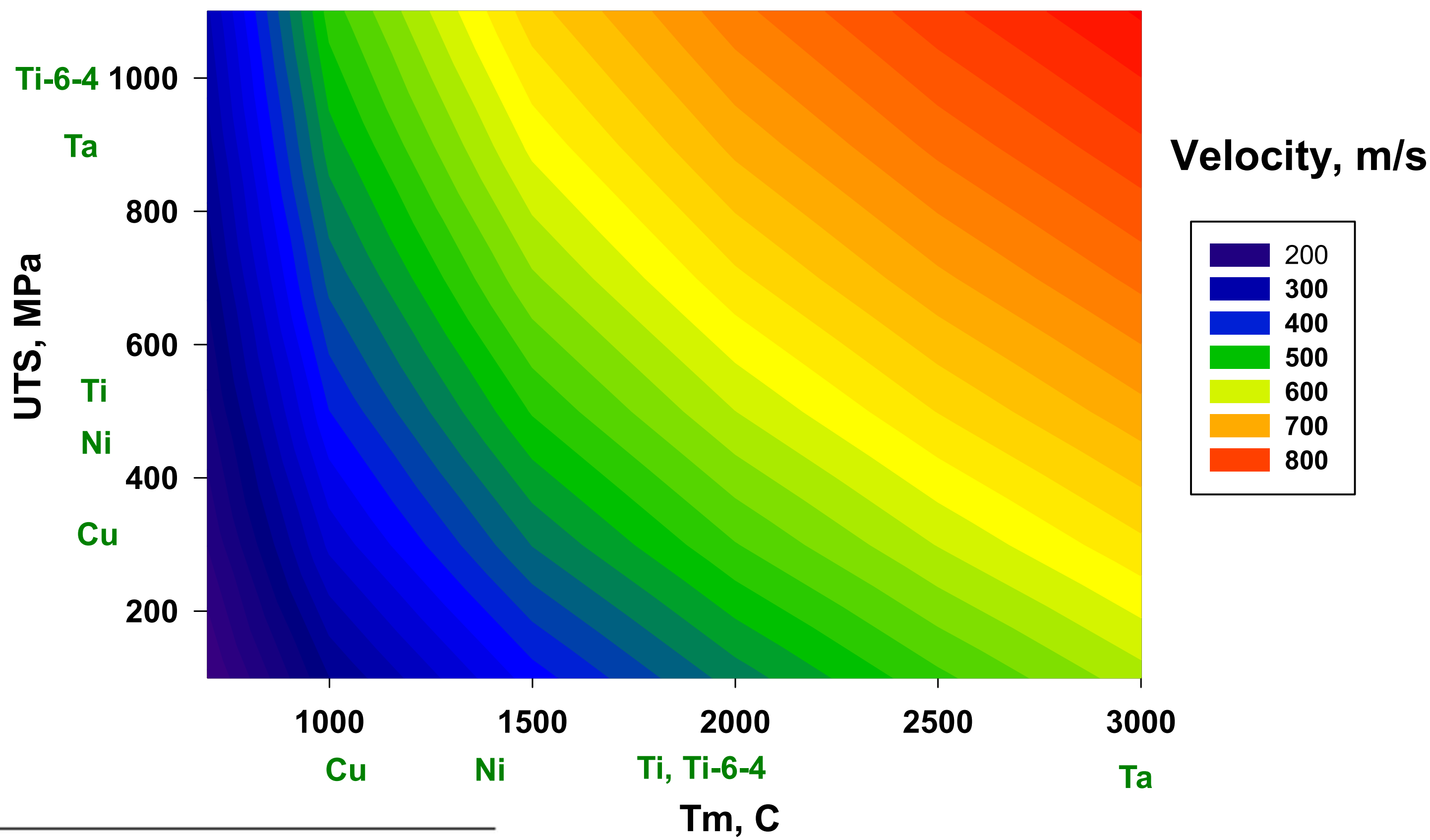
*** SSUT nozzle, nitrogen**

Nozzle Exit Velocities



SSU – type generic nozzle, nitrogen

Typical Critical Velocities

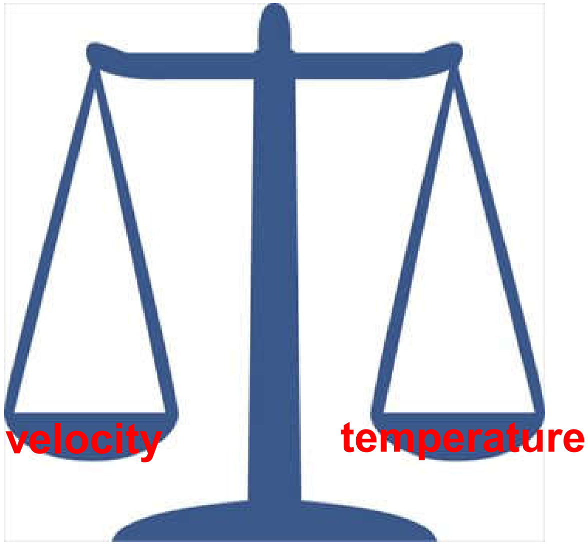


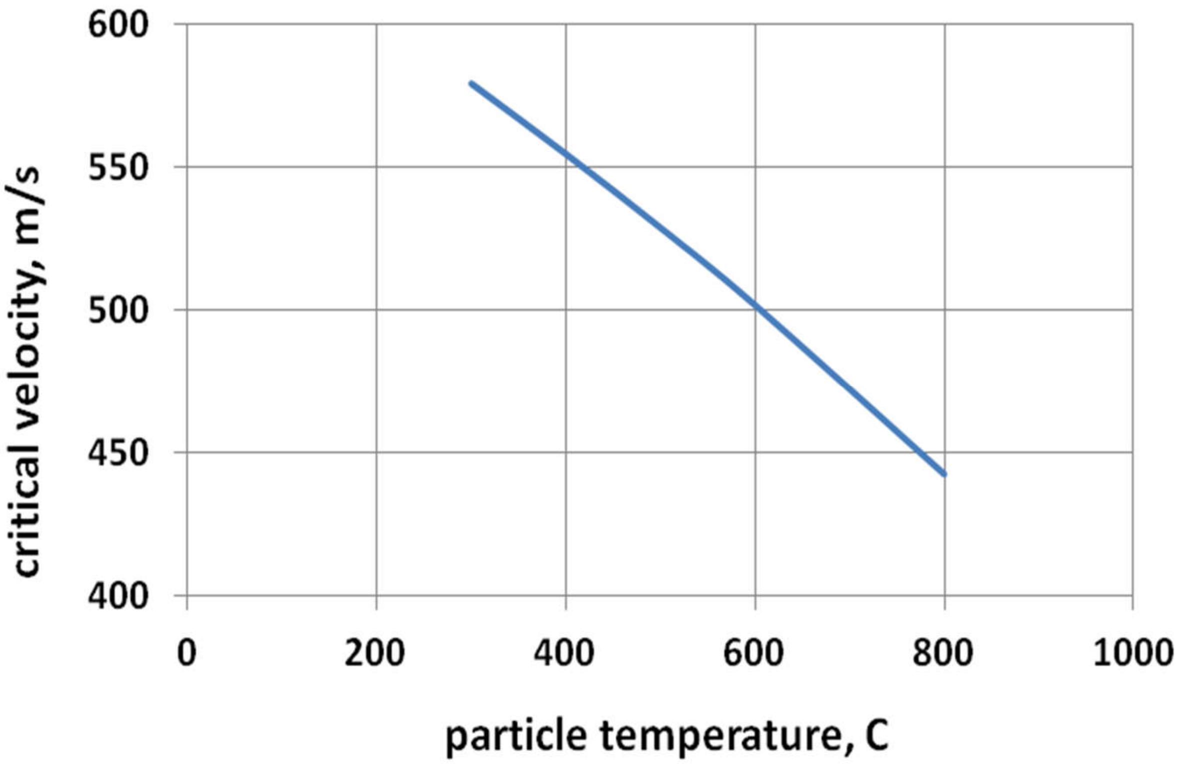
$$V_{crit} = \sqrt{\frac{4F_1\sigma_{TS}\left(1-\frac{T_i}{T_m}\right)}{\rho} + F_2C_p(T_m - T_i)}$$

F_1 = 1.2, F_2 = 0.3, ρ = 10 g/cc, C_p = 400 J/Kg-K, T_i = 600 C

Tobias Schmidt, et al, “Development of a generalized parameter window for cold spray deposition,” Acta Materialia 54 (2006) 729–742.

Velocity or Temperature

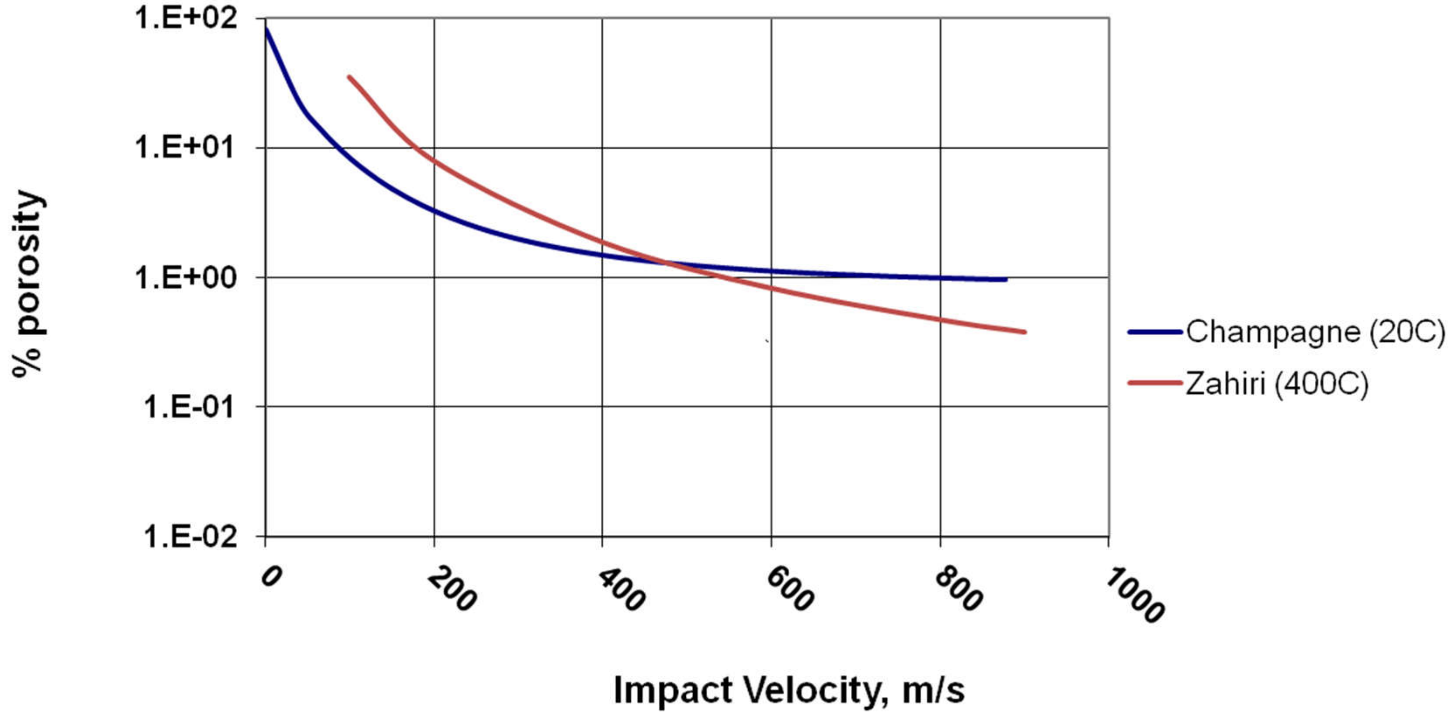




One Advantage Of Higher Velocities

$$\%porosity = 100\left(1 - \frac{\rho_0}{\rho_w}\right)\exp\left[-K(1 - f_r^{-2})^n/\sigma_y\right]$$ *

$$\log(\%porosity) = 11.66 - 2.2\log(TV) + 4 * 10^{-7}(TV)$$ **



*Champagne, et al, Research Letters in Materials Science, 2007
**Zahiri, et al, Journal of Thermal Spray Technology, 2006

Observations

- Although operating parameters vary, all systems perform well at individually rated operation, giving reasonable DE and porosity.
- The analysis provided was done for a copper powder and at maximum operating conditions for each system.
- Performances can be significantly different for other powders, and some suppliers offer powders tailored to work well for their individual system.
- High particle velocity and temperature generally yield the best deposition.
- Capital cost and throughput are the major differentials among the systems.
- Choice of system depends on the materials to be sprayed, production volume, and portability.

? Questions ?

Hand-Held Field Repairs Unit