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Inter-splat boundary effect on cold-sprayed nickel-based alloy coatings through mechanical and corrosion performance

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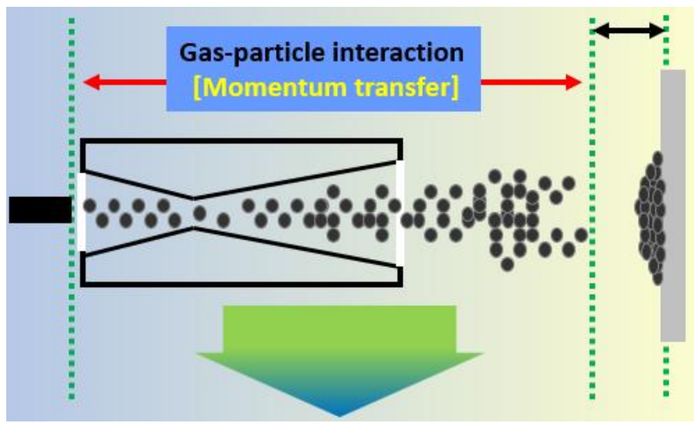
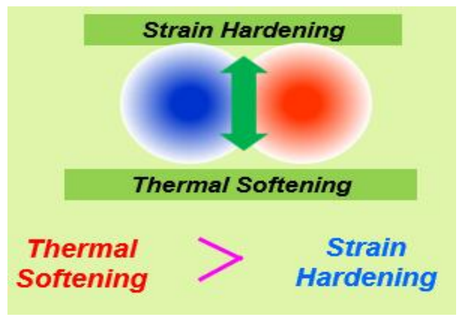
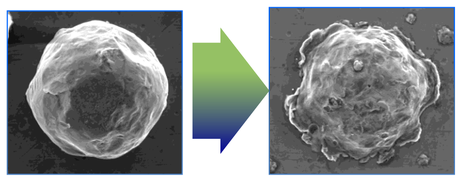
INTRODUCTION & AIM

- Cold Spraying is a solid-state deposition process. Powder particles accelerate at supersonic velocities and deform on the substrate by making mechanical interlocking and metallurgical bonding.



Schematic of the cold spray process





Objectives

1. To deposit Ni and NiCr at higher particle temperatures and correlate the inter-splat bonding state with the corrosion and oxidation resistance of the deposited coatings.
2. To deposit IN625 and IN718 at lower stagnation temperature and pressure, and understand the role of inter-spalt bonding percentage in as-coated and heat-treated conditions through electrochemical and wear studies.

METHOD

Johnson–Cook (JC) Equation :

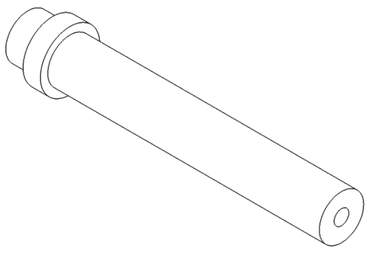
$$\sigma = \left[A + B\varepsilon_p^n\right]\left[1 + C\ln\left(\frac{\dot{\varepsilon}_p}{\dot{\varepsilon}_0}\right)\right]\left[1 - (T^*)^m\right]$$

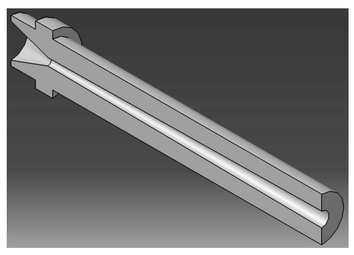
Strain hardening | Strain rate hardening | Thermal softening

S. No.	Material	Thermal sensitivity (m)
1	Titanium	0.655
2	Copper	1.09
3	Aluminium	0.895
7	Nickel	1.44
8	NiCr	1.44
9	IN625	1.146
10	IN718	1.3

- The Johnson-Cook (JC) material model is a constitutive model used to describe the behavior of metals under high strain rates and high-temperature conditions.

Different Sets of Nozzles

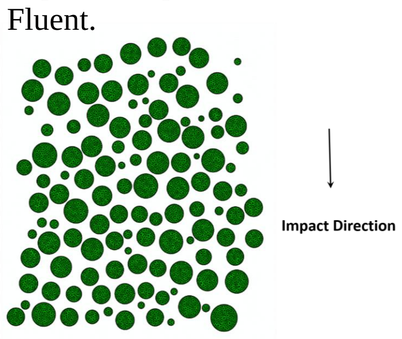


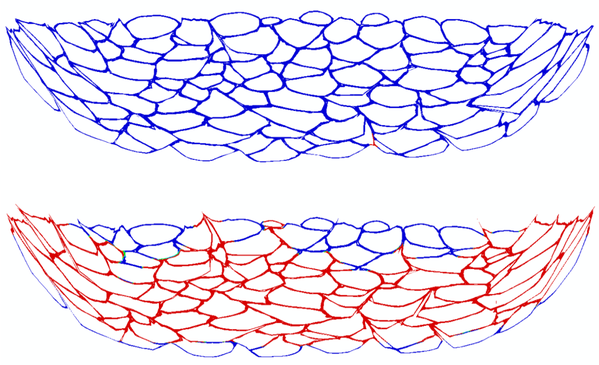


Experimental Details

Depositing Powder	Processing Gas	Pressure (bar)	Temperature (° C)	Stand-off distance (mm)
Ni	Air	15, 20	600	15
IN625, IN718, NiCr		20	600, 650,700,750,800	

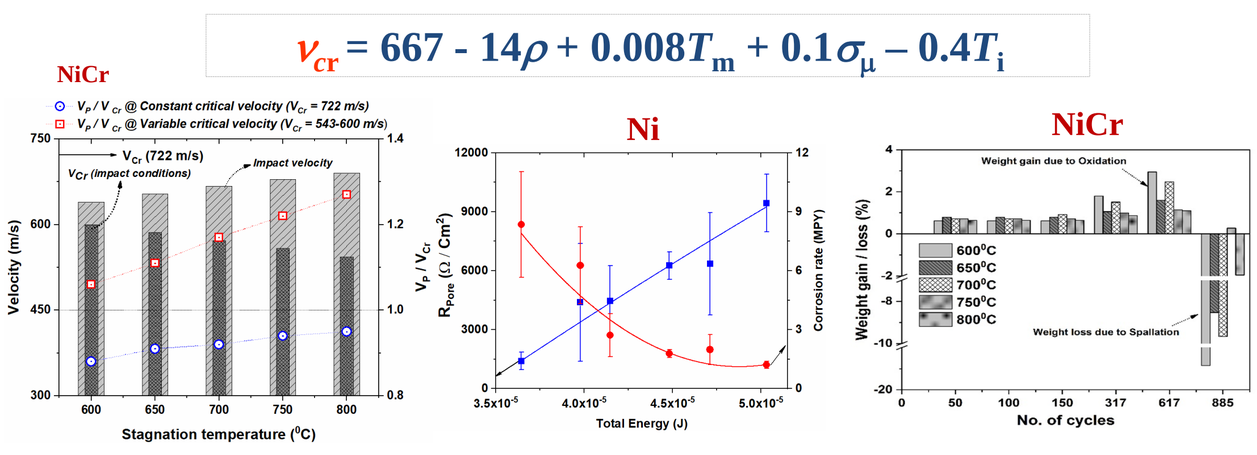
- Inter-spalt bonding percentage was estimated using the ABAQUS tool at a particular particle temperature (T_p) and particle velocity (V_p). Tp and Vp were measured using ANSYS Fluent.

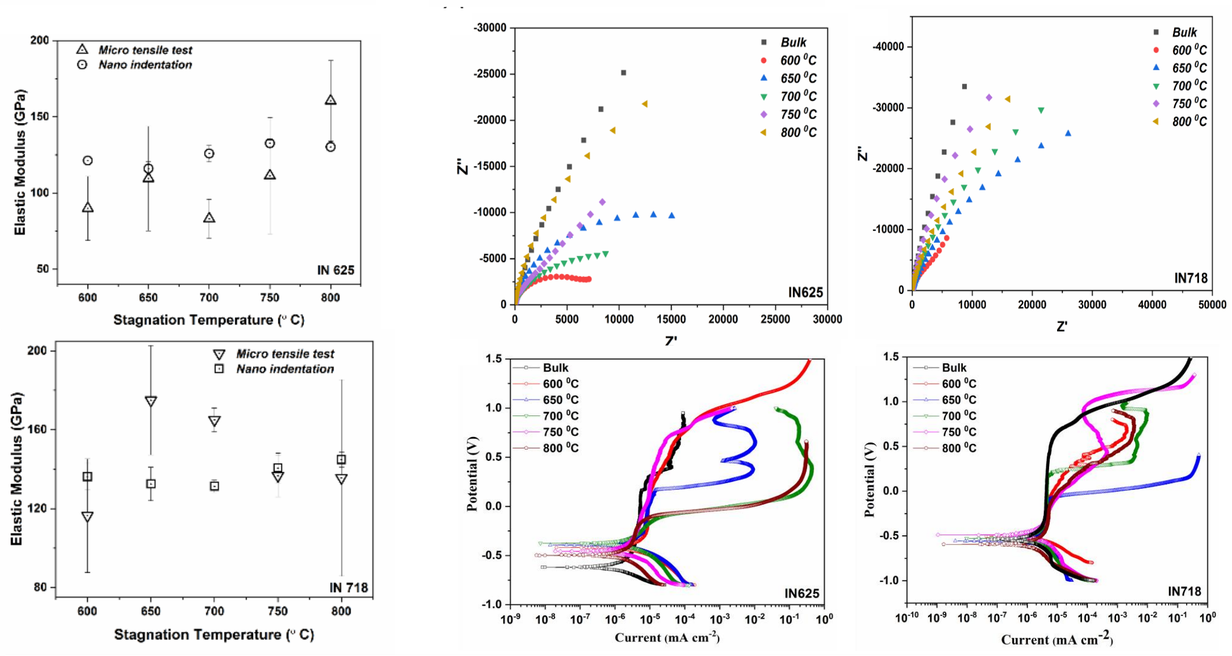




RESULTS

$$v_{cr} = 667 - 14\rho + 0.008T_m + 0.1\sigma_\mu - 0.4T_i$$





CONCLUSIONS

- Ni, NiCr, IN625, and IN718 superalloy powders were successfully cold-sprayed using air as process gas at low pressure (20 bar).
- Particle temperature (T_p) is a significant parameter, along with particle velocity (V_p), in the deposition of thermal-sensitive materials to achieve higher deposition rates.
- To get thicker coatings with good inter-splat bonding, higher particle temperatures are required. This can be achieved by increasing the nozzle convergent length or the gas temperature.
- Process property and performance correlation has been done by correlating the effect of inter-splat bonding state with functional properties of nickel-based alloy coatings such as oxidation, corrosion, tensile and wear properties.
- The deposition of high-temperature superalloys such as IN625 and IN718 using air as a process gas attracts not only academic interest but also implications in the field of repair and reclamation.

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