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Influence of Plasma Transferred Arc Cladding Parameters on Dilution and Deposition Characteristics of Duplex Stainless Steel Overlay.

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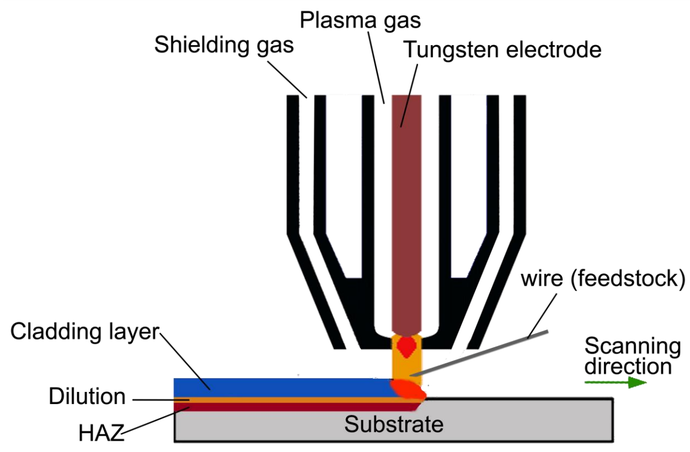
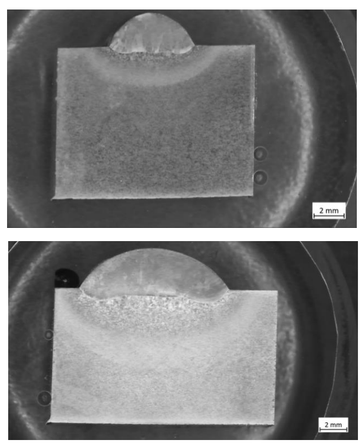
INTRODUCTION & AIM

Duplex stainless steel (DSS) cladding offers an attractive solution for combining the corrosion resistance and strength of DSS with the low cost of mild steel substrates [1, 2]. A major challenge, however, is dilution at the clad-substrate interface, which can degrade the intended properties of the DSS overlay. This study investigates the influence of plasma transferred arc (PTA) process parameters on heat input, dilution and deposition geometry.

MATERIALS & METHOD

Feedstock (wire)	DSS (Exaton Safurex); ⌀1.2 mm
Substrate	Mild steel plate (200 mm x 200 mm x 10.5 mm)
Shielding	Argon gas shielding (local), flowrate of 8 L/min
Stand-off distance	8 mm
Plasma gas flow rate	0.8 L/min
Current	150 A – 170 A
Wire feed rate	1.1 m/min – 1.3 m/min
Travel speed	1.0 mm/s – 2.5 mm/s
Heat Input	1.06 kJ/mm – 2.99 kJ/mm

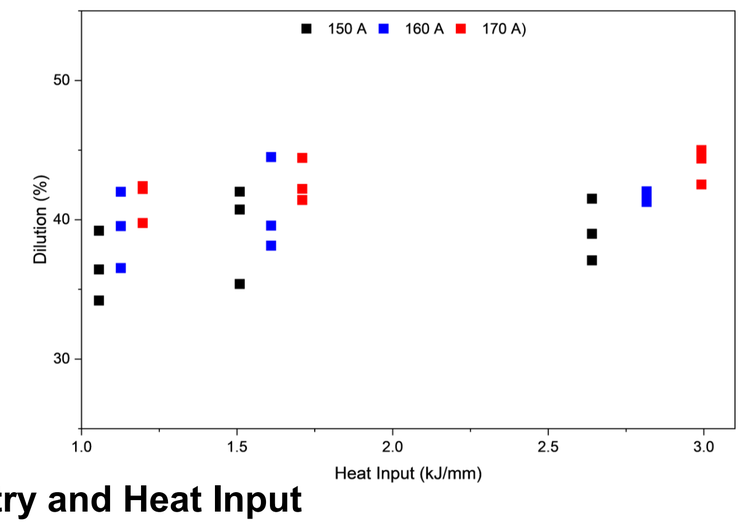




RESULTS & DISCUSSION

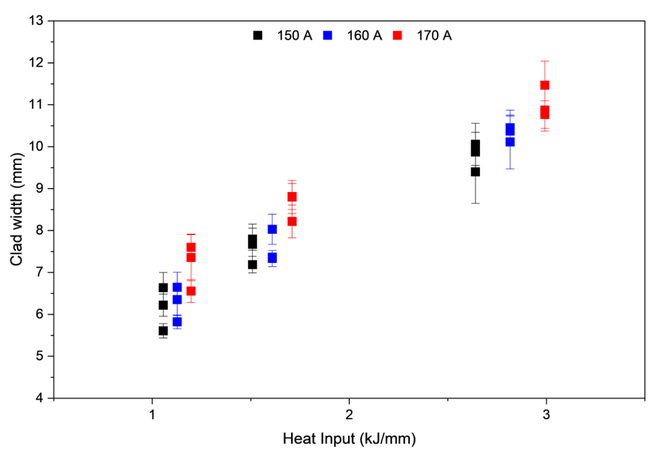
Effect of Process Parameters on Dilution

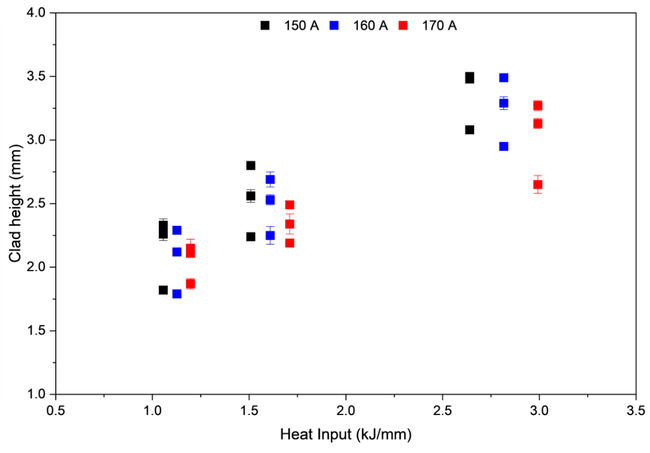
Dilution generally increased with heat input, but variations at constant heat input revealed the combined effects of feed rate and travel speed on melt pool behaviour and energy transfer. Observed range: 34.2% – 45.0%.



Bead Geometry and Heat Input

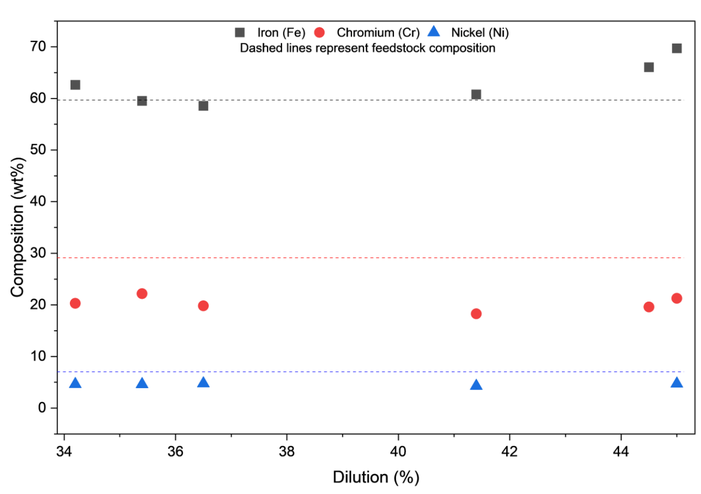
Increased heat input enhanced melt pool fluidity and wetting, producing wider beads with reduced reinforcement.





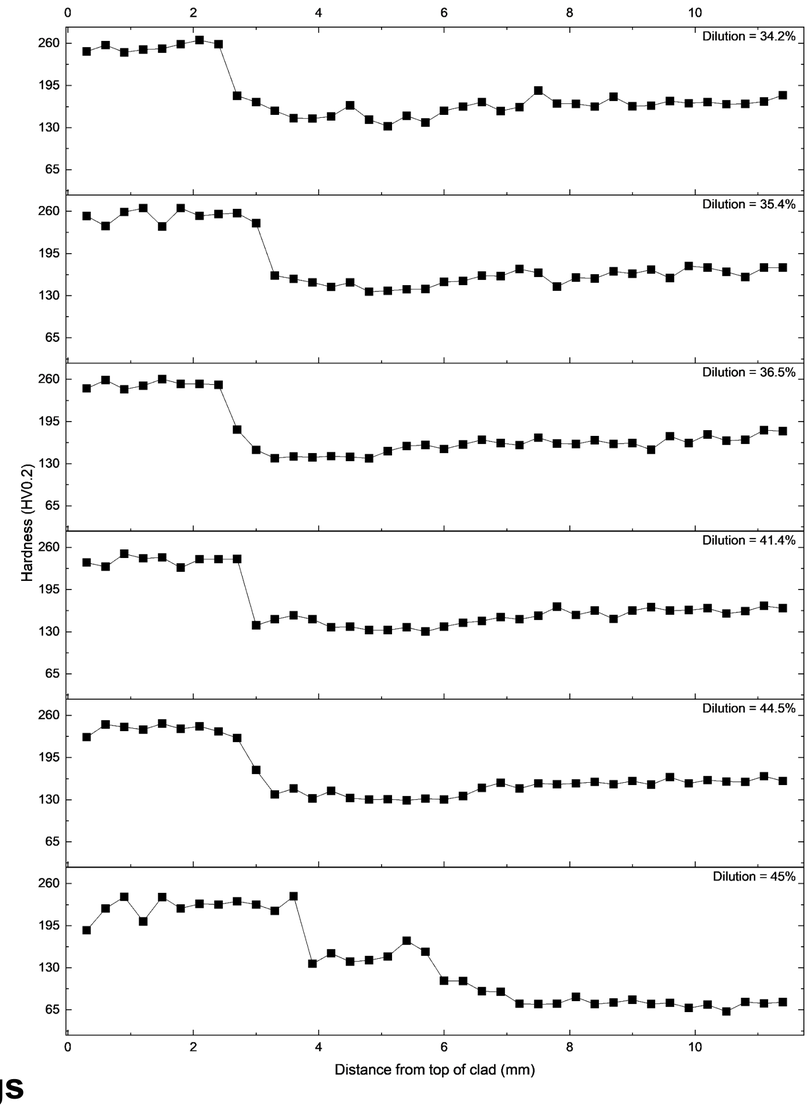
Composition (EDS)

Increasing dilution enriches Fe and depletes Cr and Ni in the clad, altering the DSS chemistry.



Microhardness

There is limited sensitivity of microhardness to dilution.



Key Findings

- Heat input (1.06 kJ/mm – 2.99 kJ/mm) is the dominant factor that governs dilution and bead morphology.
- High current + low travel speed → high dilution, deep penetration.
- Fe enrichment and Cr/Ni depletion intensify with increasing dilution.
- Hardness independent of dilution.

CONCLUSION

- PTA cladding of DSS on mild steel is highly sensitive to heat input,
- Heat input influences dilution overall, however it does not uniquely determine it.
- The derived relationships between process variables, dilution, and geometry can guide parameter optimisation for industrial applications.
- Findings demonstrates how quantitative process control enables cost-effective corrosion-resistant overlays.

REFERENCES

[1] V. Mishra, N. Yuvaraj, Vipin, A study on the performance of super duplex stainless steel cladding over mild steel using a CMT welding, J Adhes Sci Technol 39 (2025) 58–75. https://doi.org/10.1080/01694243.2024.2396120.
[2] P. Murkute, S. Pasebani, O. Burkan Isgor, Metallurgical and Electrochemical Properties of Super Duplex Stainless Steel Clads on Low Carbon Steel Substrate produced with Laser Powder Bed Fusion, Sci Rep 10 (2020) 1–19. https://doi.org/10.1038/S41598-020-67249-2.