On the maintenance of processing stability and consistency in laser-directed energy deposition via machine learning

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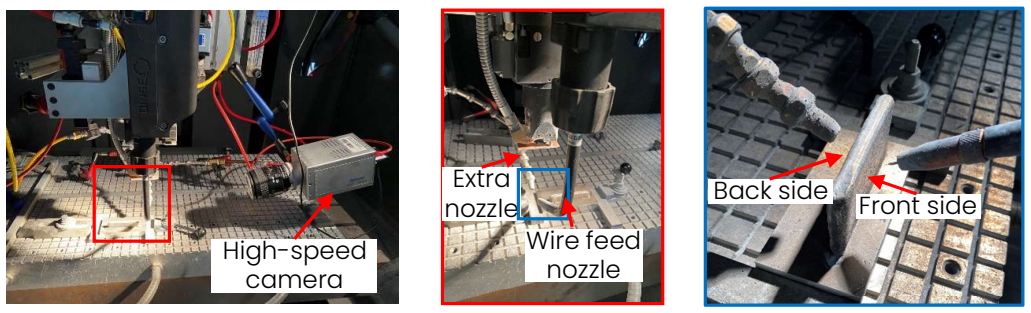
Background

- Deterioration of surface roughness and porosity level caused by asymmetrical blowing of shielding gas.
- Heat accumulation and property variation attributed to use constant process parameter in layer-by-layer deposition.
- Machine learning was adopted as a post process for quality control, while an in-situ adjustment of process parameter via machine learning has not been achieved.

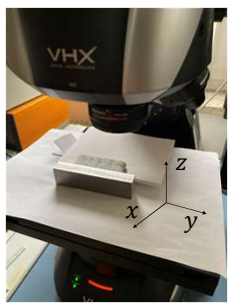
Highlights

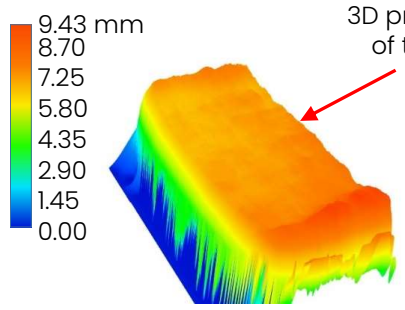
- Blowing directions of shielding gas affect the processing stability and the properties of specimens.
- An extra nozzle installed on the back side improves the processing stability.
- Efficient finding of the appropriate flow rate of shielding gas by using a convolutional neural network.
- Maintenance of processing stability and consistency by in-situ parameters adjustment with a convolutional neural network.

Experimental setup



Roughness characterization

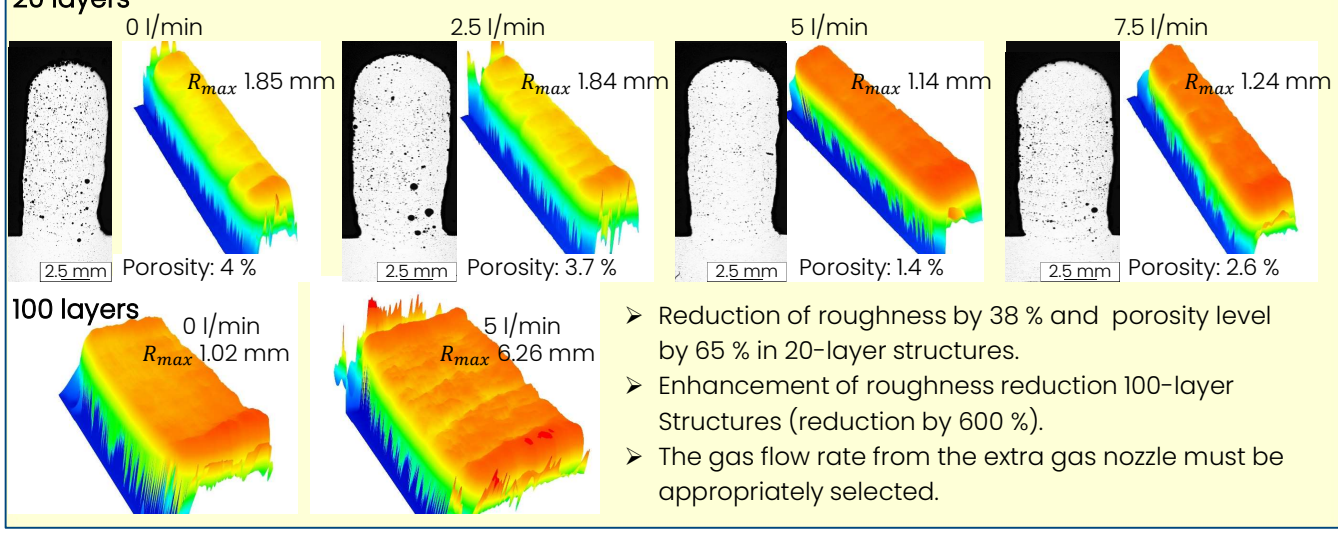




3D profile of the back side of thin-wall structures

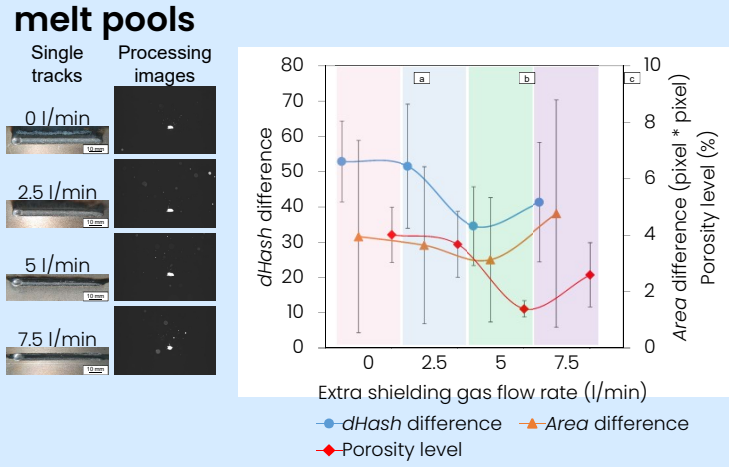
Improvement of processing stability via an self-developed shielding gas system

Effects of extra shielding gas flow on the properties of thin-wall structures (porosity and roughness)



- Reduction of roughness by 38 % and porosity level by 65 % in 20-layer structures.
- Enhancement of roughness reduction 100-layer Structures (reduction by 600 %).
- The gas flow rate from the extra gas nozzle must be appropriately selected.

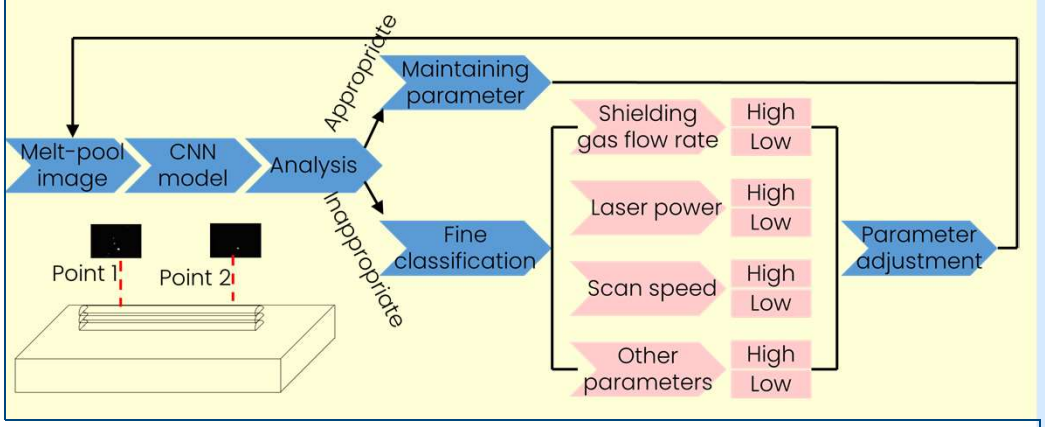
Geometrical and area fluctuation of melt pools



- Reduction of the geometrical and area fluctuation of melt pools during processing
- Improvement of processing stability

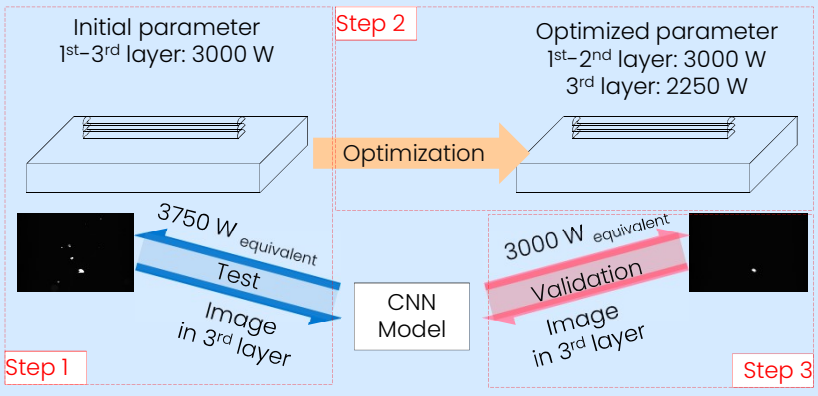
Maintenance of processing stability via machine learning

Workflow of using the convolutional neural network to Identify processing states and in-situ adjust parameters

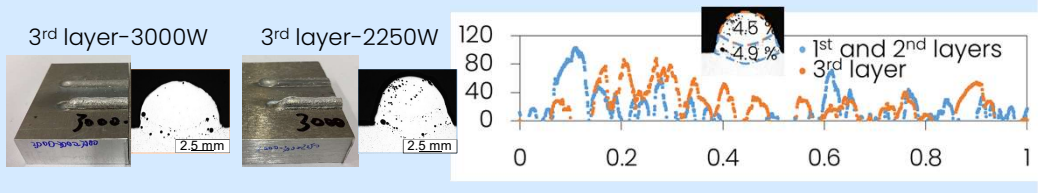


Validation of the methodology

Parameter optimization



Characterization



Conclusions

- **By installing an extra shielding gas nozzle, the porosity level and surface roughness can be reduced as it enhances the processing stability.**
- **The integration of the convolutional neural network and laser-directed energy deposition enables in-situ parameter adjustment, ensuring processing stability and maintaining consistent properties across different layers.**

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