SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

Co-funded by the Erasmus+ Programme of the European Union

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CU 01: DED-ARC

Session 5.5 – Temperature Control

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FOR SAM PILOT ATTENDEES AND TRAINERS ONLY

MM17,21

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Interpass Temperature for welding

- Temperature of workpeice or bead immediately prior to depositing next bead
- Minimum interpass temperature often equal to minimum preheat temperature
- Maximum interpass temperature not normally specified in welding

https://weldinganswers.com/dangers-of-not-maintaining-proper-interpass-temperature/

https://news.thomasnet.com/fullstory/temperature-indicator-enables-interpass-temperature-testing-801096

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Interpass Temperature for DED

- Temperature of preceding bead prior to depositing the next layer
- Unlike traditional welding the maximum interpass temperature needs to be controlled
- As more material is deposited the temperature rises
- Affects the deposition characteristics (bead shape tends to flatten)
- Can have a detrimental affect of mechanical properties
- Made increase part distortion

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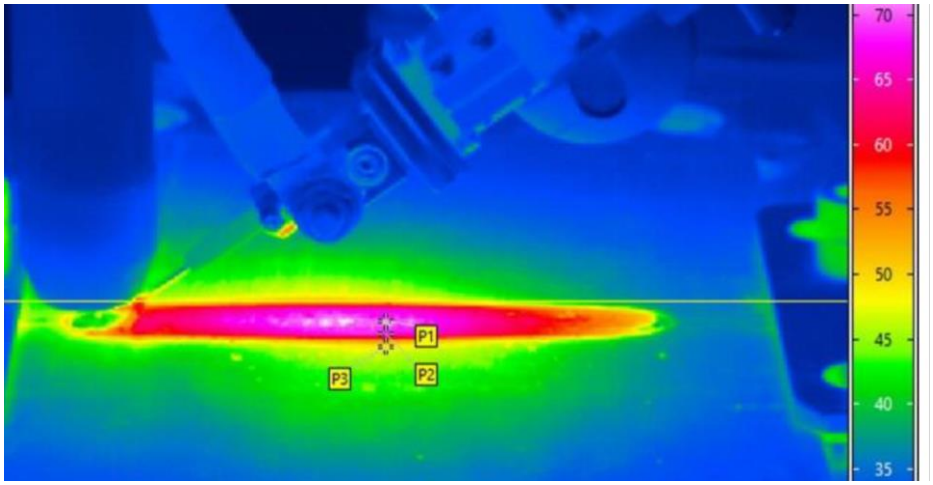
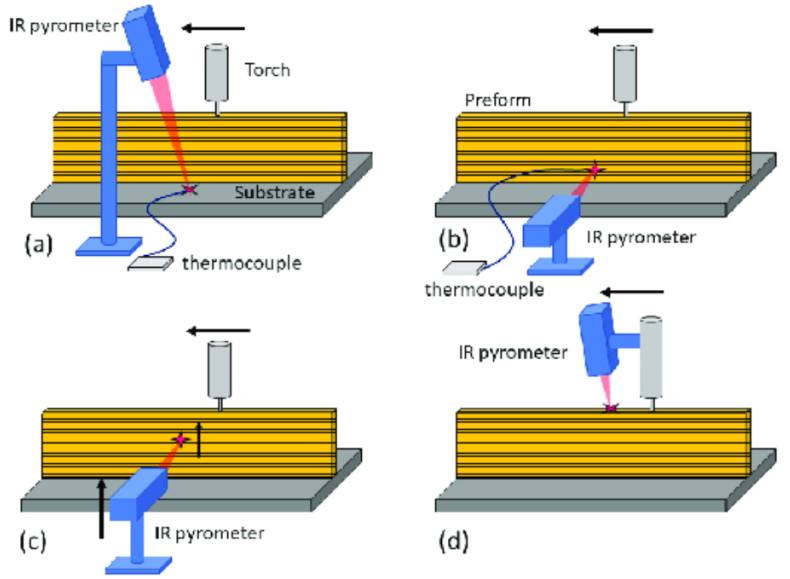
Measurement of Interpass temperature in DED

- Thermocouple or pyrometer
- Increasingly IR cameras are used



https://www.mdpi.com/2075-4701/10/8/1046/htm



Different approaches to measure AM interpass temperature: a) Fixed point at the subtract (contact or non-contac probes); b) Fixed point at a given position of the preform lateral surface (contact or non-contact probes); c) Movable point in the upright position on the preform lateral surface (non-contact probes), keeping the same distance point-top surface; d) Movable point at the top surface (non-contact probes), ahead of the arc.

The Potential of IR Pyrometry for Monitoring Interpass Temperature in Wire + Arc Additive Manufacturing

September 2019

DOI:10.31031/EME.2019.03.000553

Authors:

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Process modelling

- Welding simulation is often used to help predict the temperature and thus plan the deposition strategy
- Modelling can also be used to predict thermal stress, deformation and even microstructure

Effect of Interlayer Delay on the Microstructure and Mechanical Properties of Wire Arc Additive Manufactured Wall Structures

July 2021 · Materials 14(15):4187
DOI:10.3390/ma14154187

Project: Processing of metastable materials

Authors:

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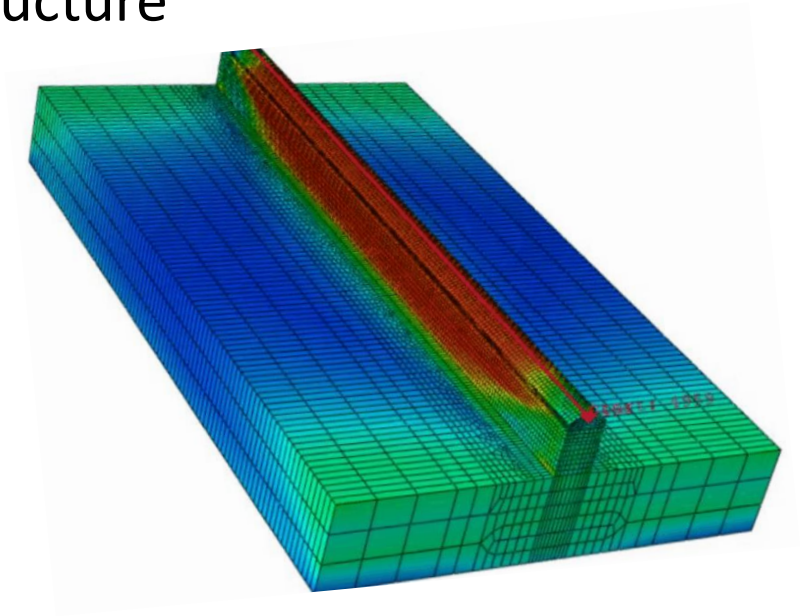

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Managing interpass temperature in DED

- Ideally maintain interpass temperatures within a relatively narrow range
- Avoid temperature dropping too low
- Once maximum temperature is reached deposition is paused until the material has cooled sufficiently to continue

BUT

- This extends the manufacturing time this undermining process productivity and ultimately increasing the costs

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Forced cooling

- To reduce this problem forced cooling is sometimes used – show image
- Typical approaches include;
- Cooled plattern beneath the build plate to help remove the heat
- Another option is to cool the deposit using blasts of air and even inert gas
- For some materials which are not hydrogen sensitive then water misting can be employed
- However, it is important to avoid cooling at a rate which adversely affects the microstructure or introduces excessive stresses in the part

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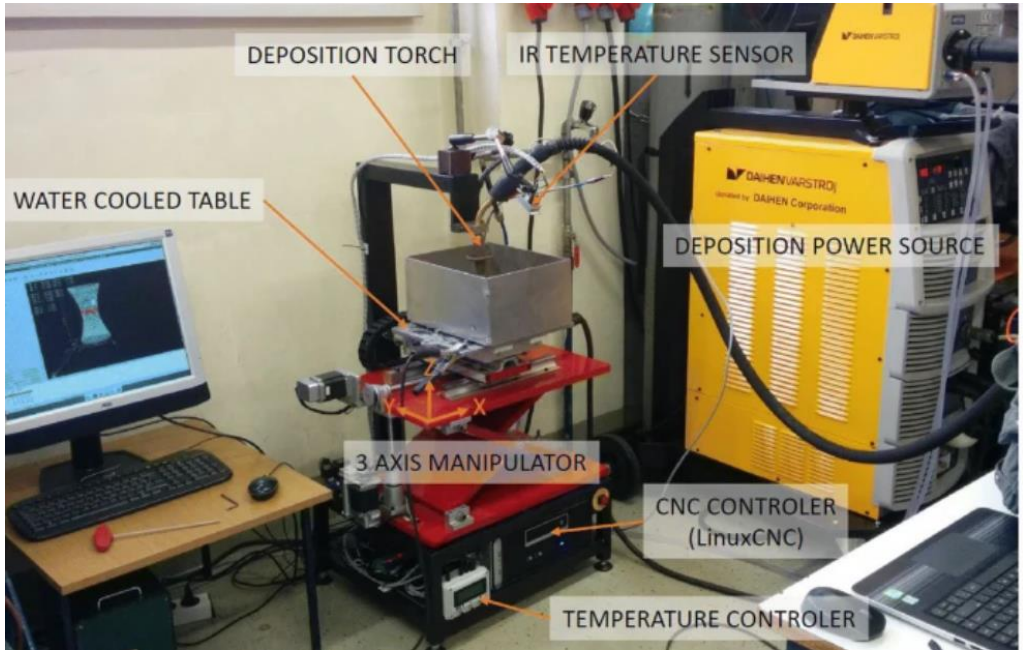


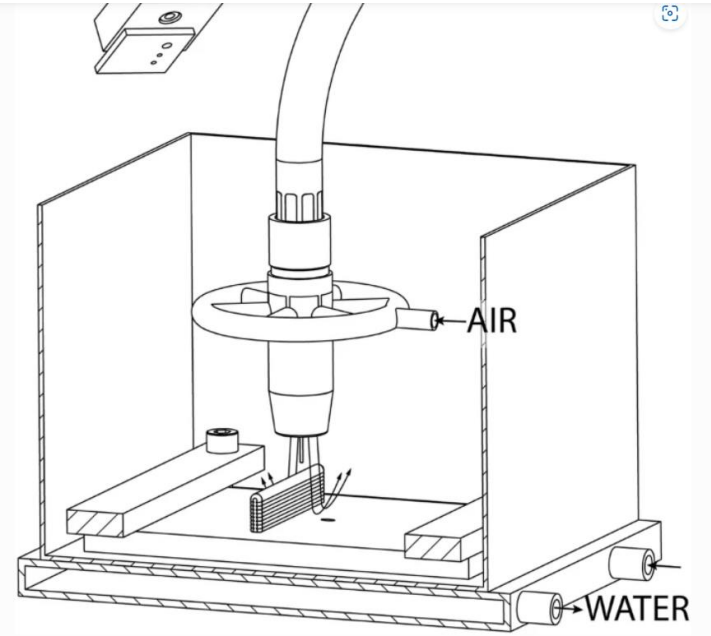
Rudimentary forced cooling used to maintain temperature of the build plate and the interpass temperature of deposited material

ORIGINAL ARTICLE | Open Access | Published: 31 August 2020

WAAM system with interpass temperature control and forced cooling for near-net-shape printing of small metal components

Nejc Kozamernik, Drago Bračun & Damjan Klobčar

The International Journal of Advanced Manufacturing Technology **110**, 1955–1968 (2020) | Cite this article



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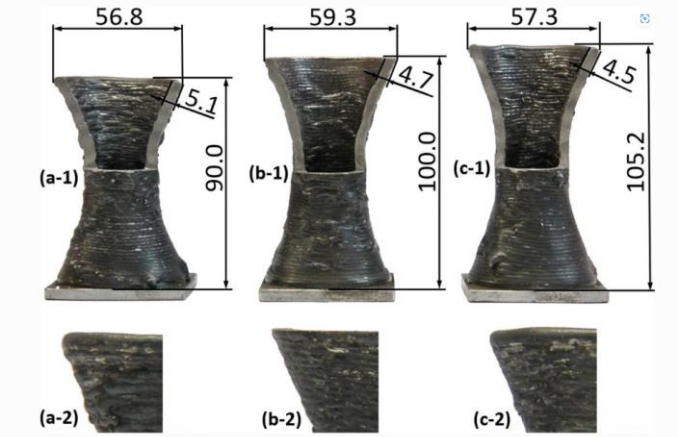
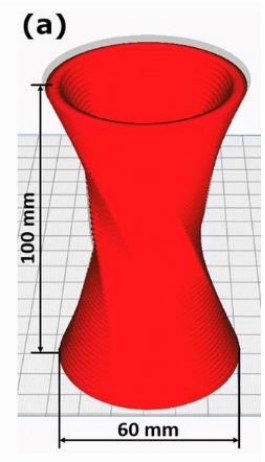
Results & conclusions

- Maintaining interpass temperature at 150 °C resulted in shape deviations of less than 2% in comparison with the CAD model.
- Unregulated interpass temperature led to significant shape distortions
- Forced aircooling removed need for dwells in the deposition increasing productivity by up to 30%
- Cooling by compressed air is safe and has no adverse effect on the microstructure and mechanical properties of structural steel.
- Interpass temperature control is critical to achieve repeatable and stable deposition height through the layers and the desired final dimensions of the deposit.



The object printed with (a) constant 3 s interpass dwell times and no cooling, (b) same as in Fig. 15, printed with temperature control and forced air cooling, (c) constant 120 s interpass dwell times and forced air cooling



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Near Immersion Active Cooling (NIAC)

Deposition performed in a tank which is progressively filled with water as the deposition process continues

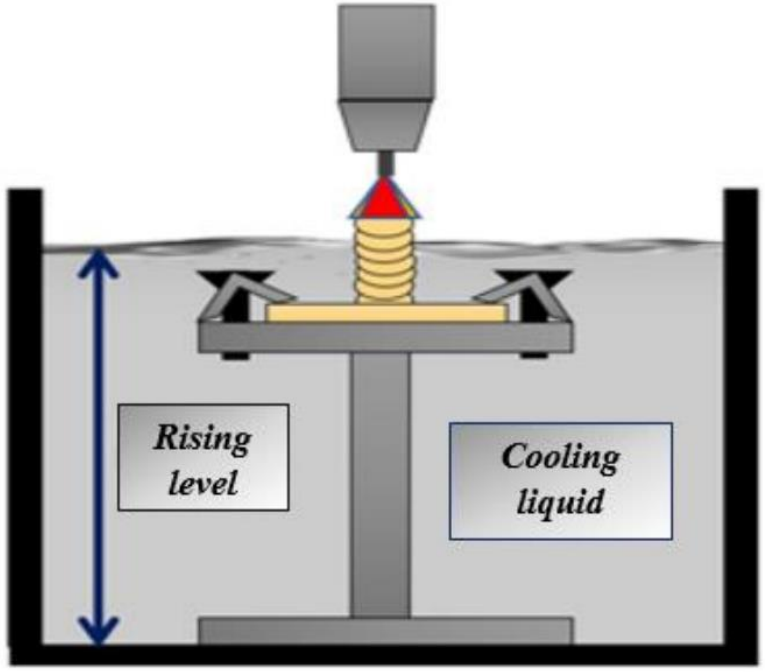

Figure 3. Active cooling technique of WAAM

Hackenhaar, William, José AE Mazzaferro, Filippo Montevecchi, and Gianni Campatelli. "An experimental-numerical study of active cooling in wire arc additive manufacturing." Journal of Manufacturing Processes 52 (2020): 58-65.

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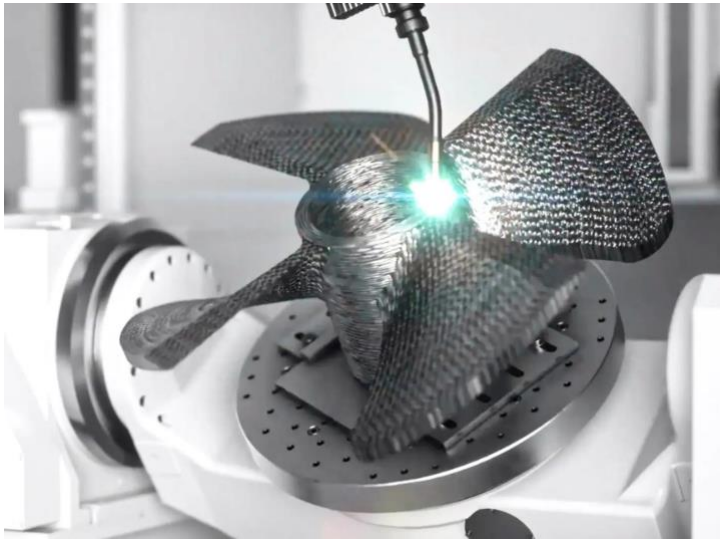
Multiple deposition sites

- One approach is start depositing in another area of the part or another part
- This maintains productivity whilst maintaining the temperature

https://thermalprocessing.com/advantages-of-wire-arc-additive-manufacturing/



https://all3dp.com/1/waam-what-is-wire-arc-additive-manufacturing/

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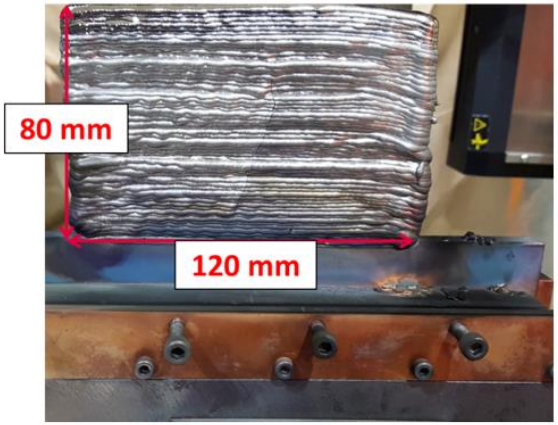
Increase in temperature along a bead

- For some materials, part geometry and weld parameters there is a significant increase in temperature of workpiece ahead of the meltpool.
- Refractory materials such as Tungsten are prone to suffer from this problem due to very slow travel speed.
- This changes the interpass temperature along the length of the bead.
- Often leads to characteristic sagging at the end of beads
- To avoid this welding parameters need to be adjusted and forced cooling implemented



Tungsten sample produced by WAAM- Cranfield University (AMAZE project)

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www.skills4am.eu

Thank you & Questions ?

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