Use of WAAM for manufacture of reconfigurable tooling with conformal features

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1.Background and Introduction

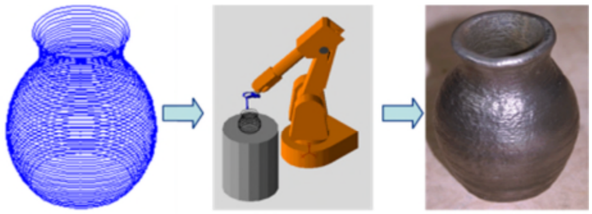


Figure 1 Basic WAAM process

Wire + Arc Additive Manufacture (WAAM) is receiving considerable interest in the manufacturing sector due to its potential disruptive effect. WAAM is a metal additive manufacture (or 3D printing process) suitable for the production of large scale engineering structures of high integrity at low cost. WAAM combines an electric arc as heat source with wire as feedstock material and then uses a robot or CNC system to produce freeform metallic structures as illustrated in Figure 1. Typically these can be produced at much lower cost and with much shorter lead times than manufacturing through traditional methods such as machining from wrought blocks or forgings. Furthermore WAAM provides the capability for producing components with higher functionality. This is through three different benefits:

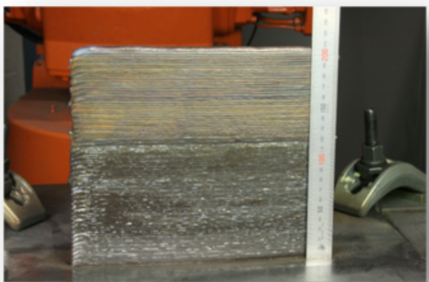
- WAAM is capable of being used for many materials and these can be easily combined to produce mixed material systems.
- Internal conformal features can be produced by sophisticated building methods
- WAAM can be combined with machining on the same system to allow for production of specific features.

These factors combined mean that WAAM technology is highly suited for the production of tooling e.g. for large composite parts.

2. WAAM technology

2.1.Materials

A wide range of materials can be manufactured using WAAM and if they are metallurgically compatible they can be combined to make mixed material systems. Of particular relevance to tooling are mild and high strength steels, invar and copper. Material properties are excellent. Figure 2 shows a steel/invar wall (invar on the top). The table shows the Invar properties directly after deposition and they are excellent as well as being isotropic. Figure 2 also shows a steel copper ring after machining.



	Peak Load (MPa)	
Invar Steel	493.8	All 3 samples failed within the Invar remote from the weld.
Invar Longitudinal	489.4	Invar alloy mechanical properties do not show significant influence by direction.
Invar Transverse	503.5	

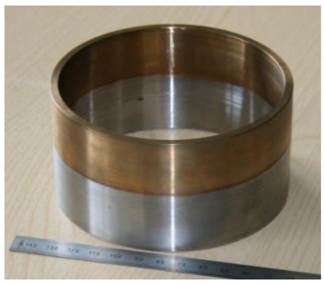


Figure 2 Invar steel wall, invar properties and copper steel ring after machining.

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2.2. Internal features

Various methods for building internal features have been developed. The first method is by patterning in the build direction and figure 3 shows a steel corrugated structure produced this way. The second is by exploiting the capability for WAAM to build free standing features in any direction. Figure 3 also shows walls built in aluminium at an angle and horizontally and an enclosed section in steel. Figure 3 also shows a triangular internal channel produced perpendicular to the building direction in a solid block. The final method is to combine deposition with machining. Figure 3 show very high aspect ratio holes in aluminium by combining deposition with drilling.

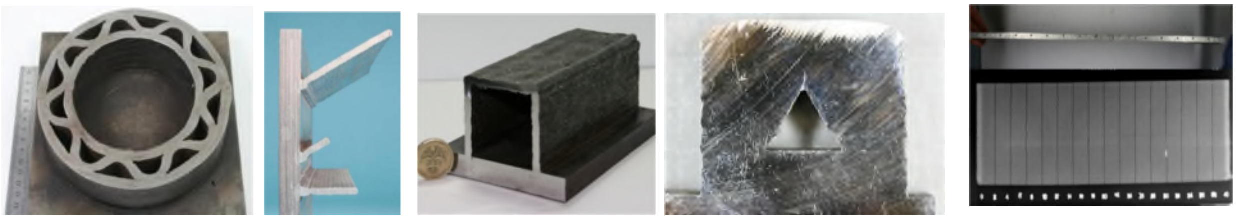

Figure 3 - Corrugated structure in steel, angled and horizontal walls in aluminium, enclosed section in steel, perpendicular channel in steel and high aspect ratio holes.

Figure 4 shows a conformal triangular channel built in a steel block and similar one produced at IIT Bombay by combining deposition with machining.

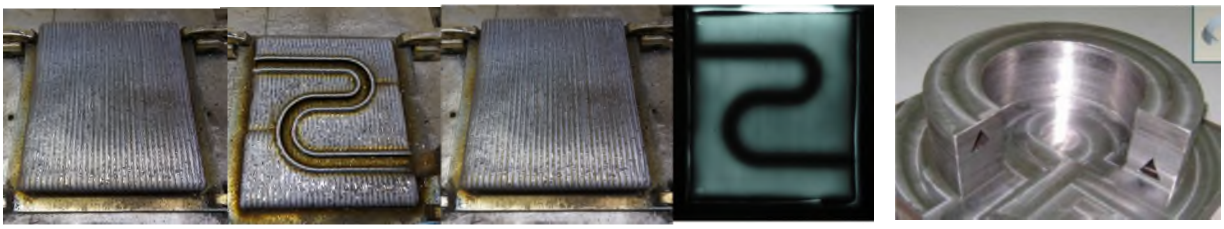

Figure 4 Production of a conformal triangular cooling channel in a steel bloc and a similar conformal channel built by combining deposition and machining (made by IIT Bombay)

3.WAAM technology for manufacture of tooling

The capabilities shown above make WAAM highly suitable for the manufacture of tooling for large parts such as composite panels. The following major benefits can be highlighted

- Direct manufacture should prove more cost effective than machining from solid blocks of wrought or forged material
- Drastically reduced lead times
- Repairable by reprofiling after wear or accidental damage
- Reconfigurable if the required profile changes
- Use of mixed materials allowing
    - Reduction in use of expensive materials such as invar
    - Incorporation of high thermal conductivity material such as copper to
        - Improved productivity through accelerated heating or cooling
        - Improved quality by providing localised heating or cooling
- Inclusion of conformal channels for the introduction of distributed and/or localised cooling or heating

If you are interested in exploring these potential benefits please come and talk to us.

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