Parachèvement de pièces métalliques fabriquées par procédé WAAM

Processing and finishing of metal parts manufactured by WAAM process

Thibault AGIUS

Co-founder & CEO

AXIVE ADDITIVE

30 nov. / 1er déc. 2022

ESPACE AUGUSTE COLMAR

Journées Traitements et parachèvements de pièces issues de fabrication additive

ASSOCIATION FRANÇAISE DU TITANE
The French Titanium Association

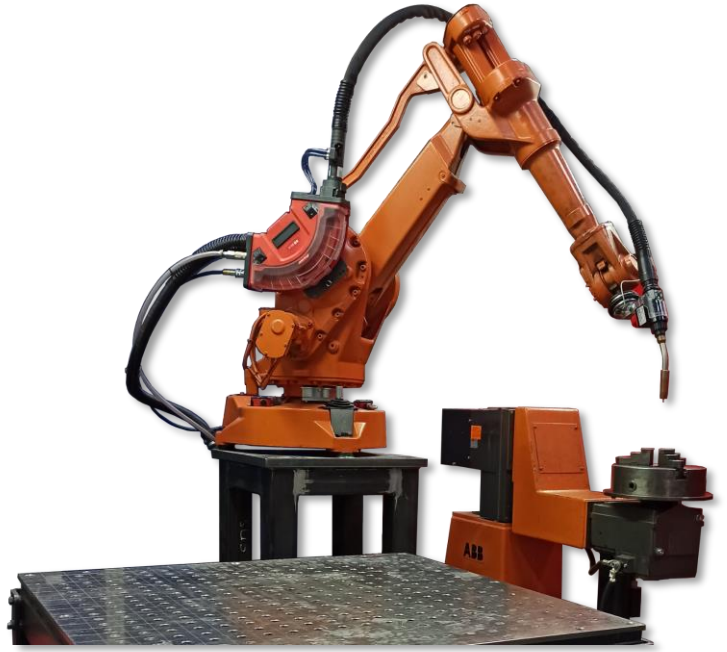
A3TS

IRT M2P Institut de Recherche Technologique Matériaux Métallurgie et Procédés

AXIVE ADDITIVE

The company:

- Created in late 2020
- 3 employees
- Localization: Saint-Etienne, France

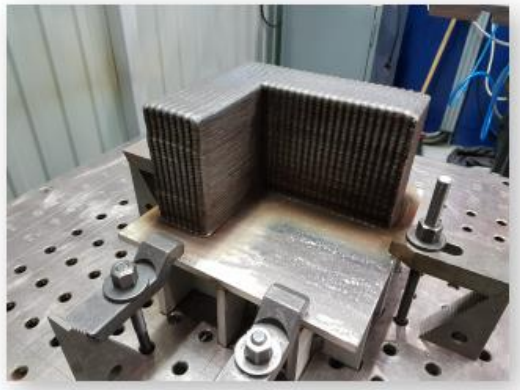


Services:

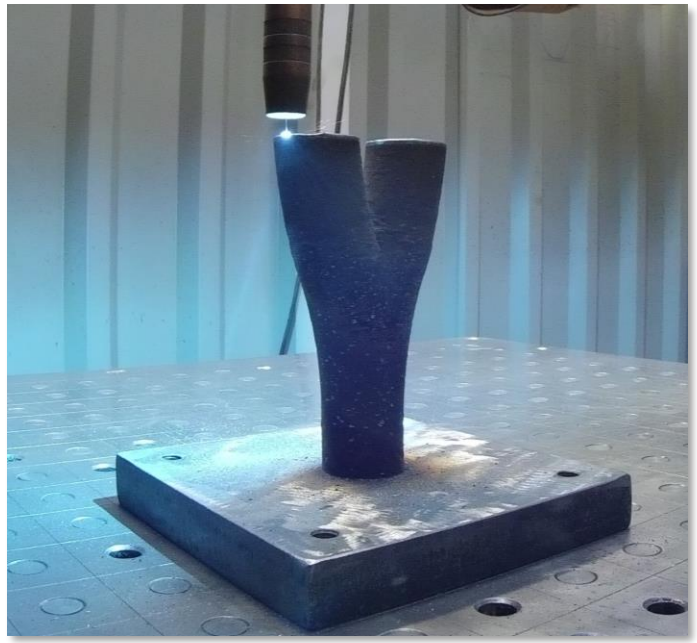
FABRICATION

REPAIRS

STUDIES

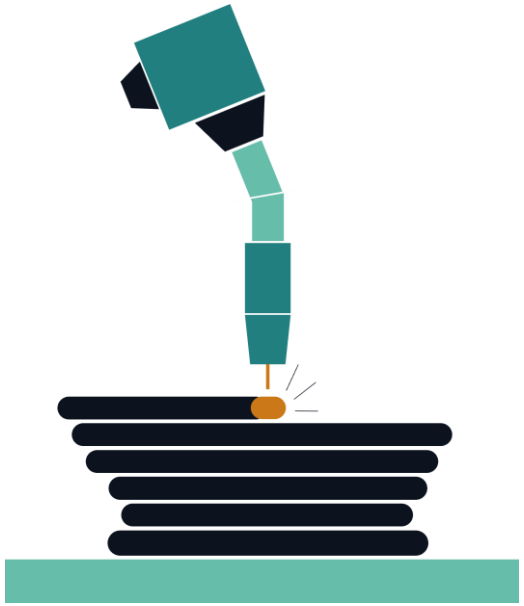


Our technology : WAAM



WAAM (Wire Arc Additive Manufacturing)

- Wire-DED process
- Additive welding: 3D parts fabrication
- Near net shape process



Advantages

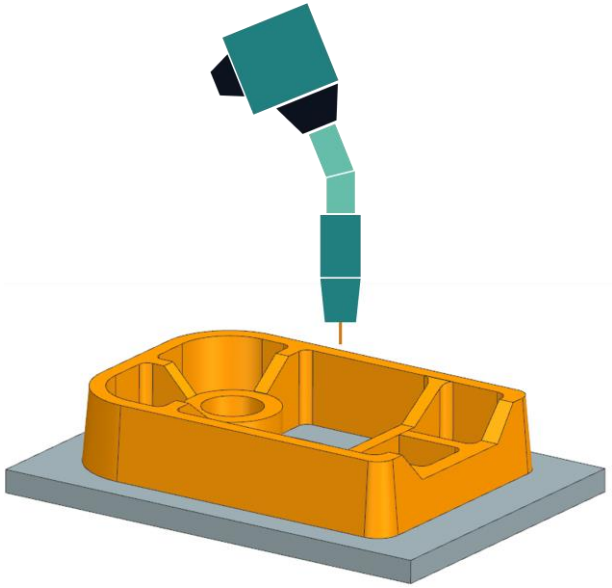
- Material savings
- Large scale
- Complex geometries
- Competitive costs
- Short lead times

Material

- Steels
- Stainless steels
- Aluminiums
- Nickel based
- Cobalt based
- Copper based
- …

Possibilities

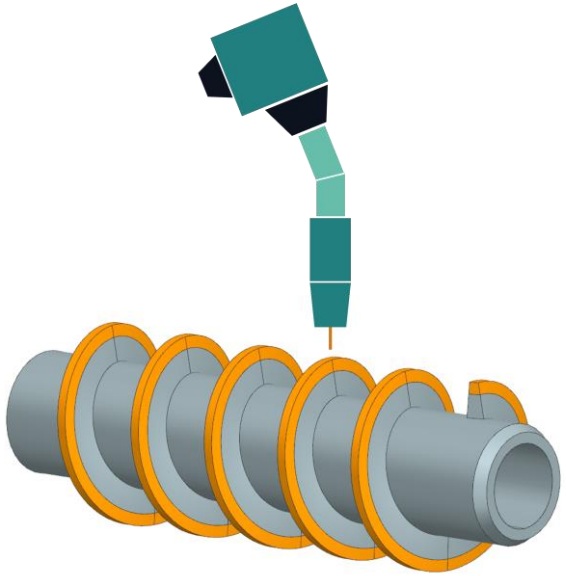
FABRICATION



Additive manufacturing

Full 3D fabrication of parts layer by layer

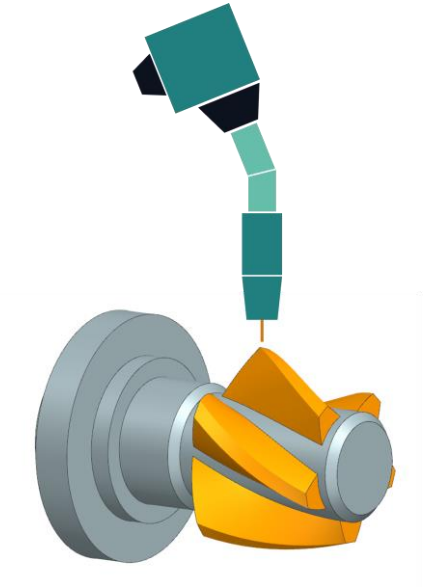
REPAIRS



Partial repairs

Repairs of used or damaged parts

FUNCTIONALIZE



Adding functions

Adding geometries on existing parts

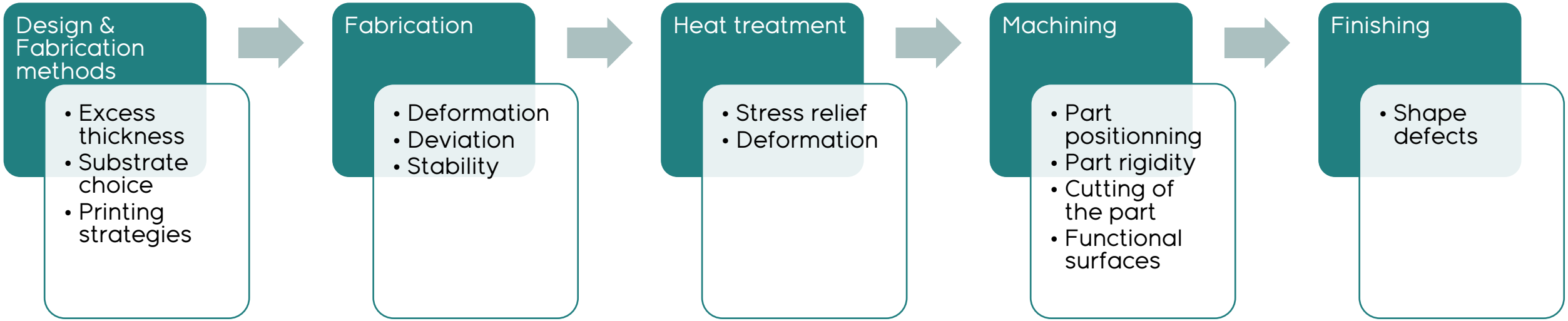
Processing and finishing of WAAM parts

Goals:

- To go from a blank to a finished part
- To make the **necessary surfaces** functional
- To homogenize the aspect of the parts

Possible operations:

- Grinding
- Sand blasting or shot blasting
- Machining
- …

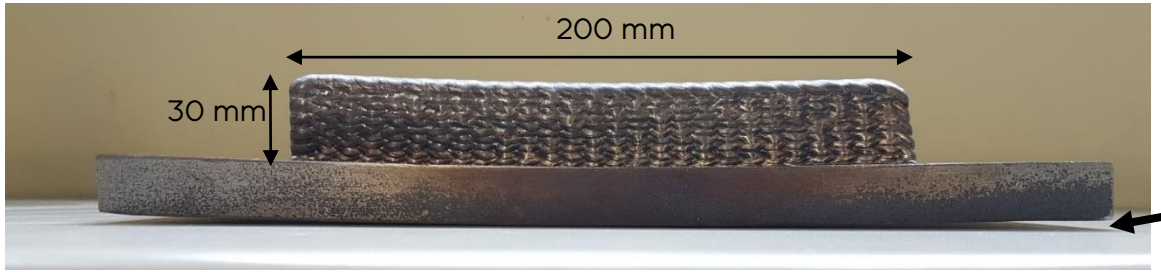


Substrate choice

Welding deformations must to be taken into account

Impacts on deformations:

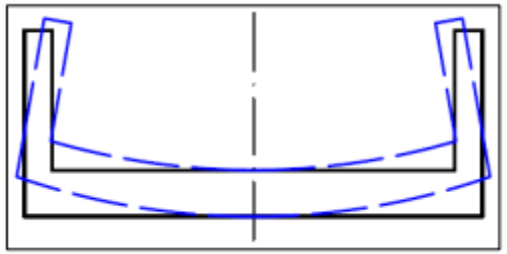
- Substrate choice
- Clamping choice
- Thermal management

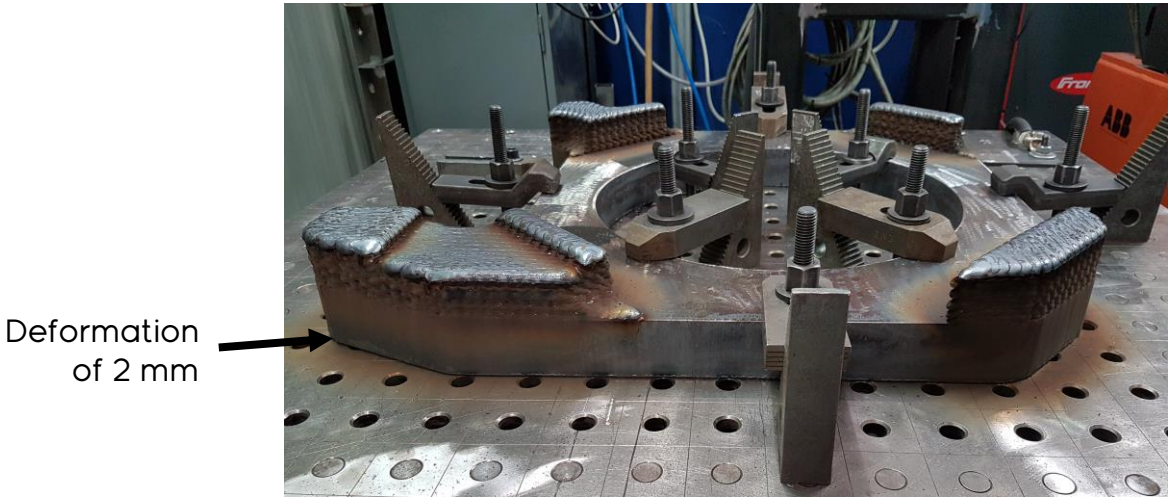


Steel substrate deformation 15mm thick

Goal: Anticipate deformations

- To respect geometry accuracy
- To minimize extra thickness
- To minimize machining





Steel substrate deformation 50mm thick

Substrate choice

Integrated in the part when possible

- Can be more economical
- Symmetrical fabrication possible

Positionning for machining

- Use the substrate for positionning
- Easier reference taking
- Extra geometry might be needed

Cylindrical substrate used for machining references

Fabrication of an axisymmetric part

Substrate choice

Cutting the part of the substrate

- Plasma cutting
- Oxycutting
- Grinding
- Band saw
- Full machining

- Extra geometry and/or thickness might be needed
- Be careful of the feasibility regarding the application

Extra cylinder needed to fully machine the part

Band saw cutting of a part from its substrate

Impact of heat treatment

Goals:

- Eliminate internal stress induced by the process
- Limit the risk of deformation during machining
- Improve the mechanical characteristics of the parts
- Improve the resilience of parts in service

Possible heat treatments:

- Stress relief
- Complete cycle (can be applyed between roughing and finishing steps)

Heat treatment of metal parts (photo credit : CASTMETAL)

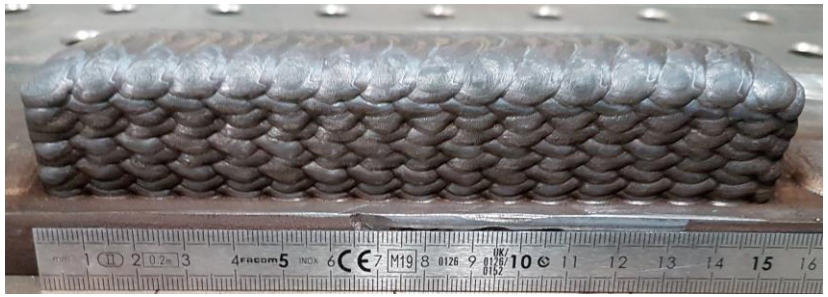
Impact of printing strategies

Zigzag filling:

- Rough shape defects = alternate cutting
- Possible hard oxide layer on the surface
- Side effects

→ Lateral extra thickness 3-4 mm

→ Top surface extra thickness might be over 5 mm



17-4PH thick wall with zigzag strategy

Machining of the side surface

Machining of the top surface

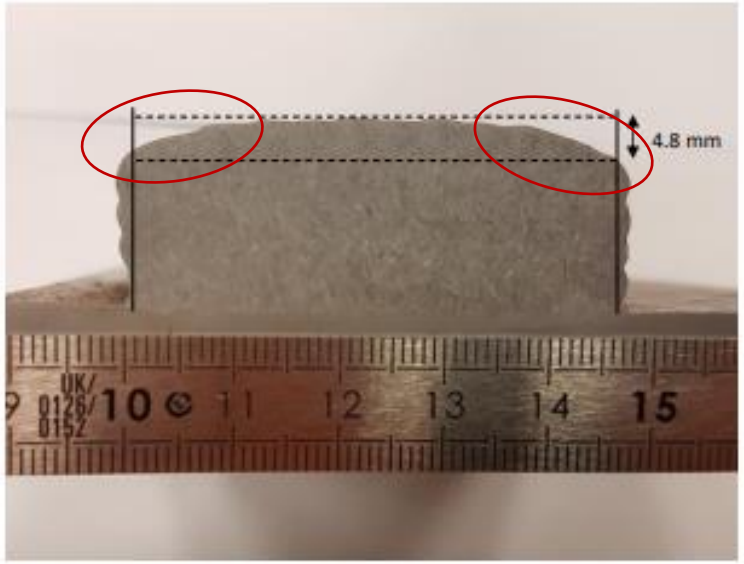
Impact of printing strategies

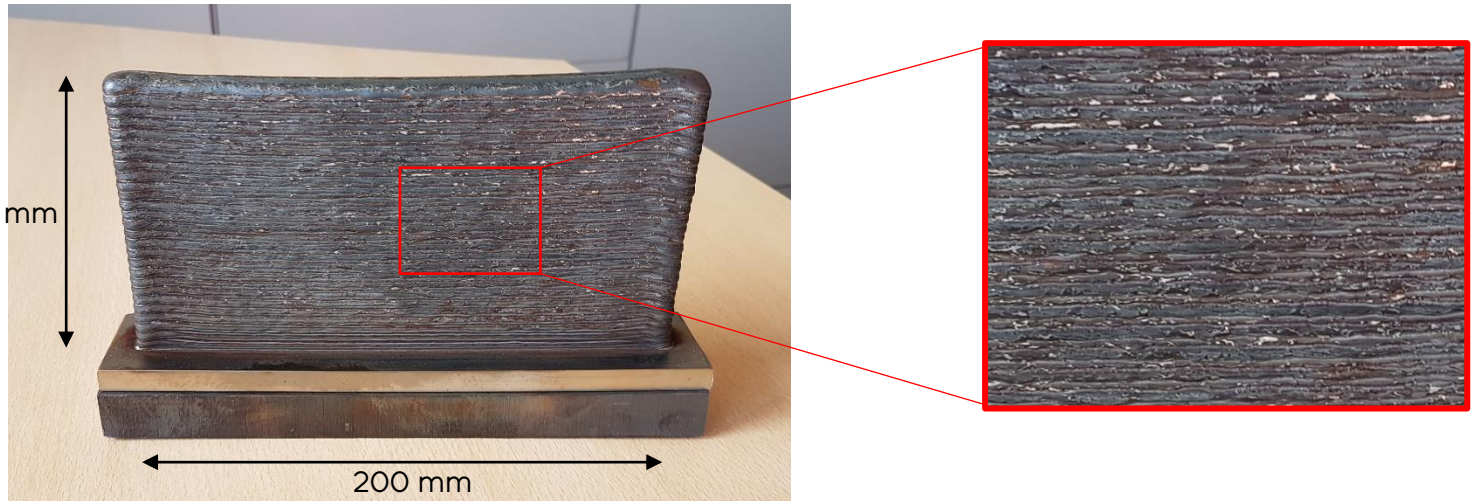
Parallel filling:

- Better lateral quality
- Side effects

→ Lateral extra thickness 1-3 mm

→ Top surface extra thickness might be over 4 mm





316L as-built wall: parallel filling strategy

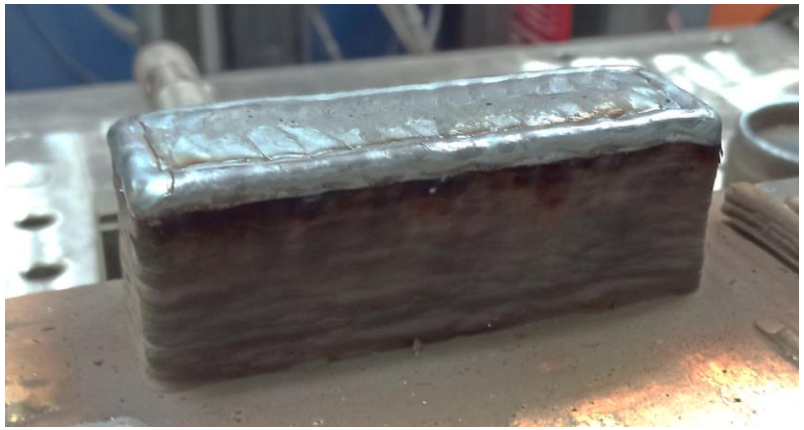
Impact of printing strategies

Hybrid strategy:

- Less side effects
- Better lateral surface quality

→ Lateral extra thickness 1-3 mm

→ Top surface extra thickness can be less than 3-4 mm



Hybrid filling strategy on a test bloc

Coating-like layer for different surface smoothness and potentiel finishing

Impact of thermal management

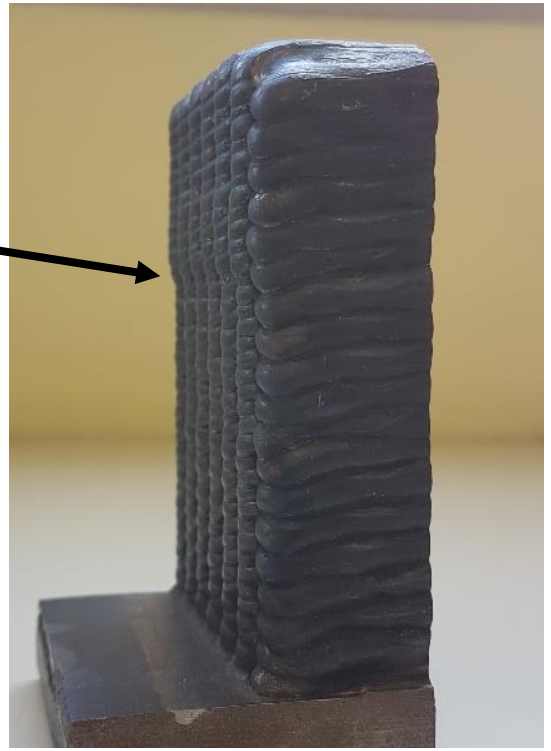
Interpass temperature control:

- More stable geometry and mechanical properties

→ Better print quality

→ Less geometrical defaults

Lateral offset du to complete cooling



Test wall with lateral offset

Aluminium wall with uneven temperature interpass: instabilities

316L thin wall with constant interpass temperature: stability

Case of thin wall parts machining

Thin wall parts:

- Smooth lateral surface
- But low rigidity!
- Possible deformation during roughing step ⚠

→ Still extra thickness needed

→ Stress relief heat treatment is mandatory

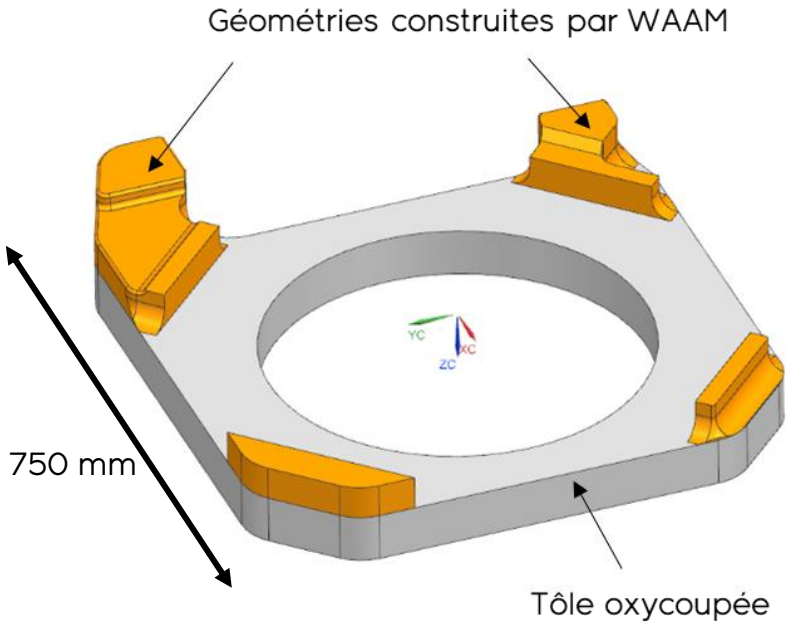
Smooth lateral surface of a thin wall part

Example of a blank thin wall part in 361L and the 3 mm thin finished part

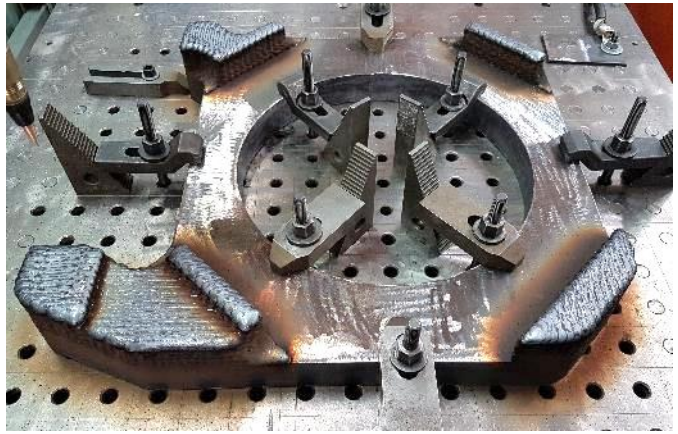
Use case of a half machined WAAM part

Only functional surfaces were machined

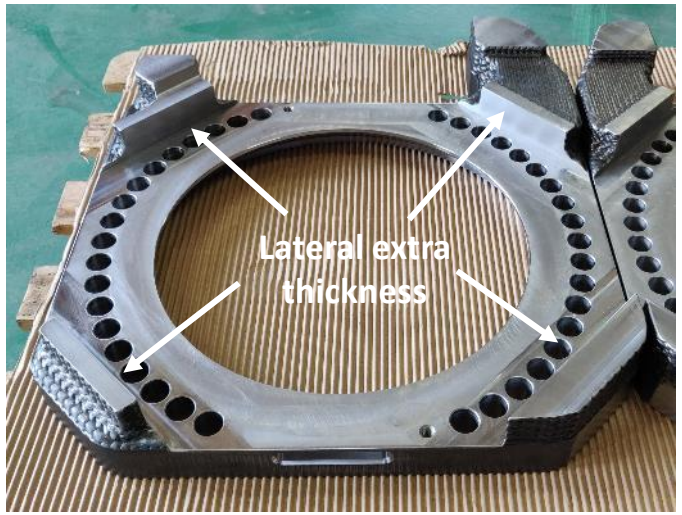
Hybrid fabrication:

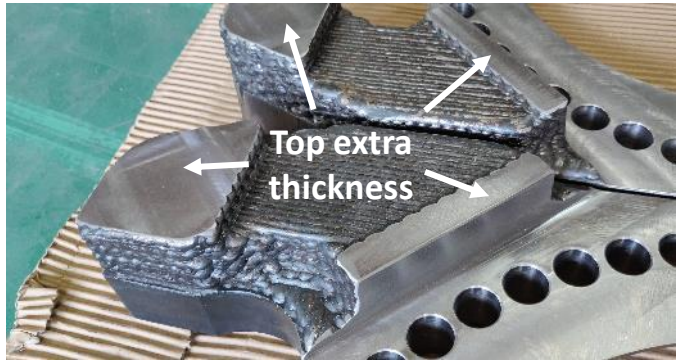


CAD Model



Blank parts





Finished part

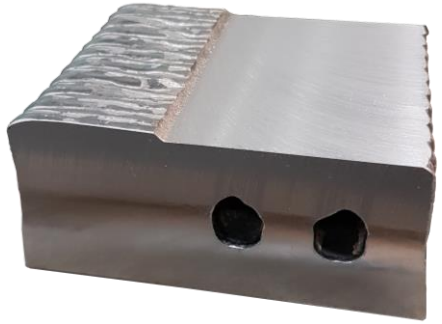
Use case of a half machined WAAM part

Monobloc parts with internal geometries:

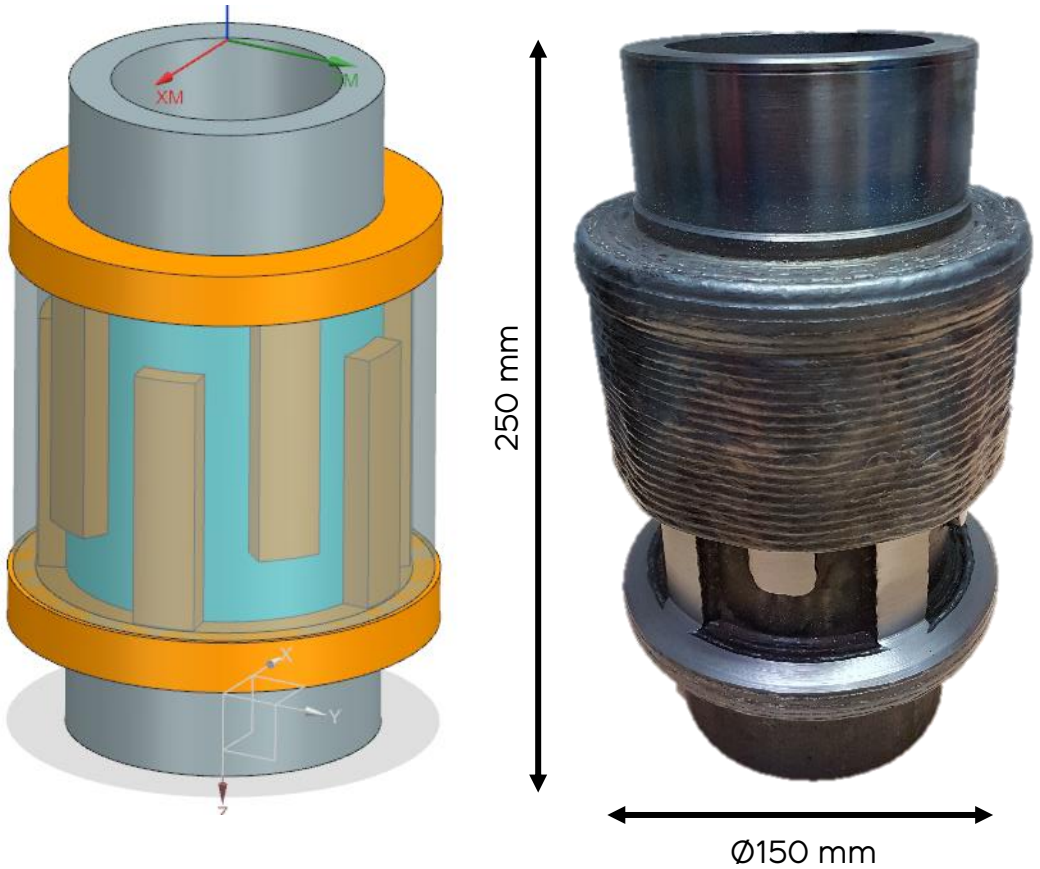
- E.g. Conformal cooling channels
- Unmachinable internal surfaces
- Different printing strategies leading to different internal shapes and smoothness

→ More surfaces = better heat exchange

→ Shape defects = turbulent flow



POC of a part of a mold with conformal cooling channel (« U » shape)



POC of a monobloc heat exchanger

Thank you for your attention!

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Thibault AGIUS et Eddy BERNOU, co-founders of AXIVE ADDITIVE

Our supports: