New method for fast predictions of Additive Manufacturing processes

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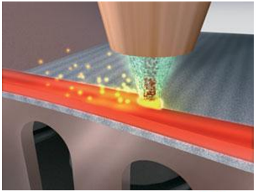
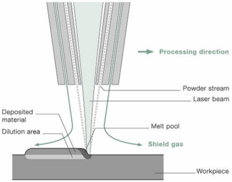
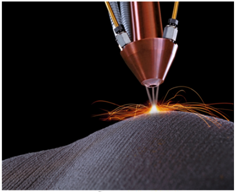
November 10, 2015

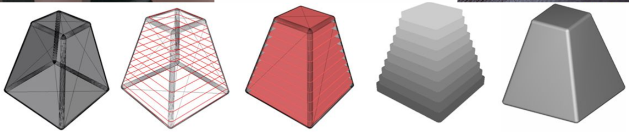
MOTIVATION OF ADDITIVE MANUFACTURING

Additive manufacturing (AM), also known as 3D printing or rapid Prototyping, is a relatively novel technique to make parts, layer upon layer, directly from 3D model data.



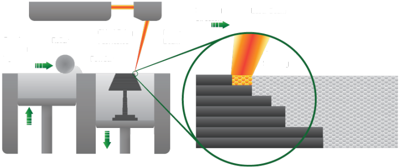




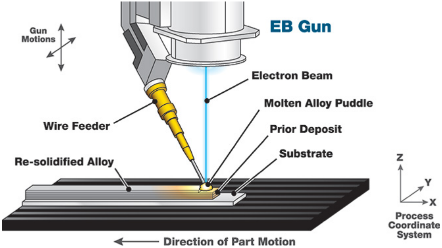


CAD File | Numerical Slicing | Layer Processing | Layer by layer Manufacture | Final Component

METAL POWDER TECHNOLOGY



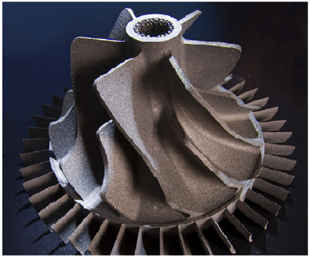
(a) Powder bed

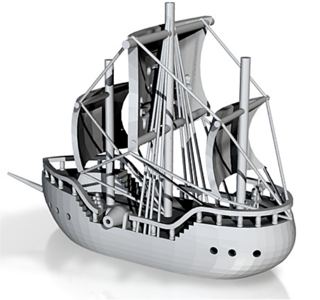


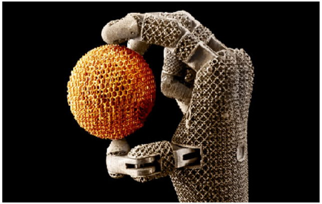
(b) Blown powder

Figure: Metal powder technology

EXAMPLES OF AM PRODUCTS







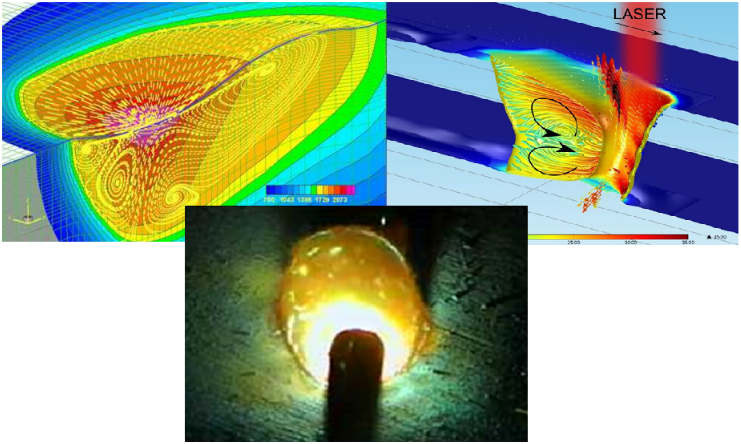
ADVANTAGES OF AM

- Freedom of design (complex shapes, inner cavities, thin walls...)
- Reduce energy and material use (no mould...)
- Rapid cooling (finer grain size)
- Large number of products can be created
- No assembly required

OBJECTIVE AND BACKGROUND

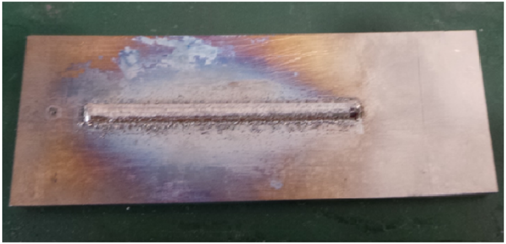
HIGH-FIDELITY NUMERICAL SIMULATION OF AM

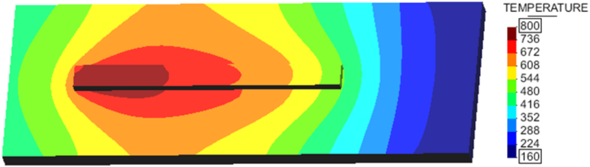
A current code developed by Michele Chiumenti, among others researchers, performs an accurate simulation of AM processes.



HIGH-FIDELITY NUMERICAL SIMULATION OF AM

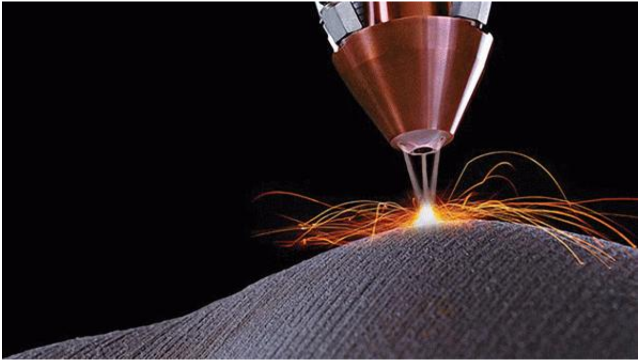
In practice, this simulation requires a high computational cost which leads to long computation times. It is difficult to apply it directly to industry.





OBJECTIVE

Reducing the computational cost to make it feasible for industrial applications.

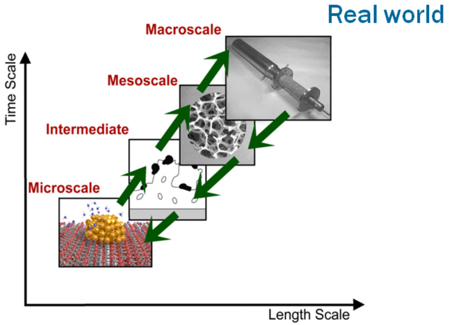


METHODOLOGY

METHOD FEATURES

The main features of the method are:

- Multi-scale approach based on FEM
- Calibration of heat source
- Analysis of scanning strategies
- Generation of the so-called "mechanical layer equivalent" (MLS)



Microscopic scale → Heat source model

For the calibration of the heat input, a thermal Finite Element Analysis (FEA) is used to determine:

- Parameters of heat source
- Energy absorption coefficient η

For the laser spot a Goldak heat source is used.

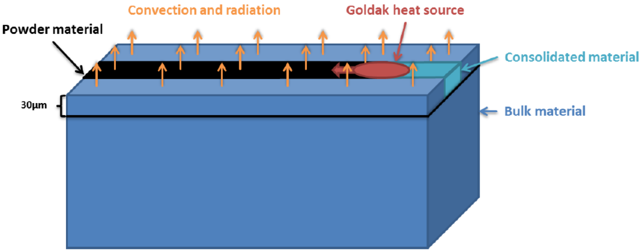


Figure: Boundary conditions of heat source simulation model

Mesoscopic scale → Hatching model

For consideration of the trajectory of the laser spot, a thermo-mechanical elasto-plastic simulation model is developed.
The energy absorption coefficient η is used for estimating the heat input which is distributed within a cubic element.
In this stage of the simulation, the so-called inherent strains of the hatching model are computed.

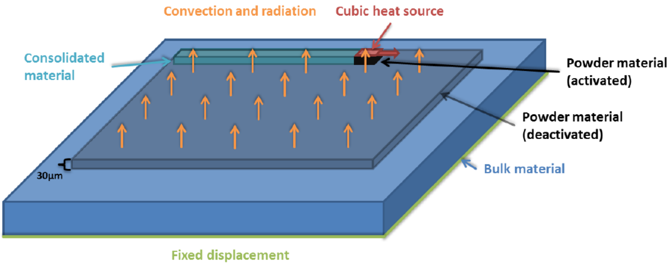


Figure: Boundary conditions of the hatching simulation model

Macroscopic scale → Layer model

- Distortion of AM parts tends to be a macroscopic phenomenon which depends on hatching strategy and geometry
- Fast solution mechanical problem with inherent strain method

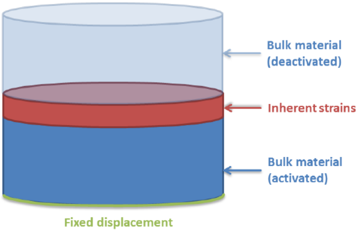


Figure: Boundary conditions of the layer simulation model

CONCLUSION

CONCLUSION

The strong points of this new fast method are:

- Numerical fast prediction of complex AM parts
- Multi-scale approach makes possible the consideration of scan strategies and complex material behaviour
- Inherent strain approach enables the reduction from a complex thermo-mechanical problem to a simpler structural-mechanical one
- Calculation time can be reduced in two or more orders of magnitude
- Opening the way for the application of this method in real industrial praxis

THANK YOU FOR YOUR ATTENTION!