Finite Element Thermal Analysis of Metal Parts Additively Manufactured via Selective Laser Melting

UNIVERSITÀ DEGLI STUDI DI TRENTO

Eurocoating EXCELLENCE AS YOU DESIGN IT

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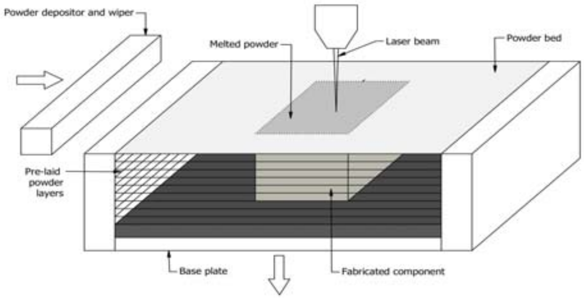
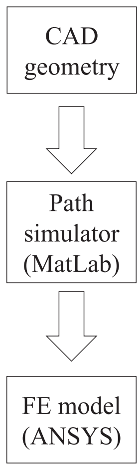
Introduction – *Selective Laser Melting*

This works aims to study the temperature distribution of the molten pool in *Selective Laser Melting* (SLM) processes. SLM is a near-net shape manufacturing process able to produce highly customized surgical implants. They are layer-wise built through selective melting of a Ti-6Al-4V powder bed. Results from the FE analysis provide guidance for setting up the optimization of process parameters and develop a base for further residual stress analysis.



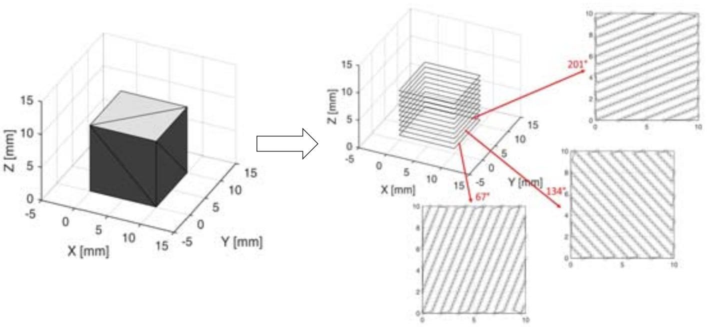


- Tessellation of the part being simulated

- Slice the geometry
- Apply laser path to each cross-section
- Generate laser spot coordinates for each layer

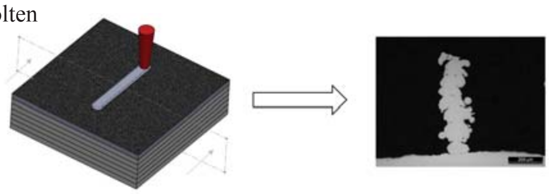
- Calibration procedure
- Dynamic mesh refinement

Path simulator – *from CAD geometry to hatched planes*



Calibration procedure – *numerical results improvement*

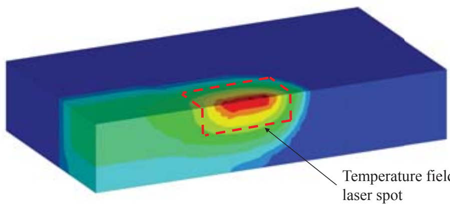
Numerical results are greatly affected by the several simplifications applied to the FE model. Material properties and boundary conditions can be modified trying to fit numerical results with experimental data The comparison is based on the molten pool dimension measured from a laser-melted seam.



Dynamic mesh refinement – *computational time reduction*

1. Special care is taken in devising a mapped mesh discretization scheme, ensuring that the travelling subdomain centered on the laser spot changes as less as possible the mesh of the remaining subdomains.

Laser spot at location (*x*,*y*) Laser spot at location (*x*+Δ*x*,*y*)

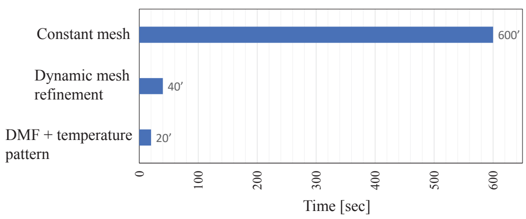


Temperature field sorrounding the laser spot

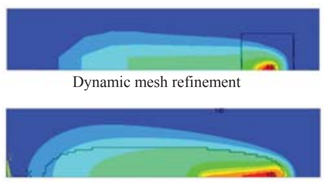
2. It has been observed that the temperature field near the laser spot is constant and it is not affected by the surrounding material. Therefore, the laser heat flux can be replaced with a repeated temperature pattern applied to the travelling subdomain.

3. Dynamic mesh refinement ensures highly reduction in computational costs while maintaining a great accuracy of the numerical results.

Solution time for a single spot



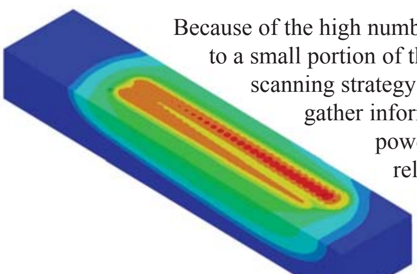
Comparison between thermal fields



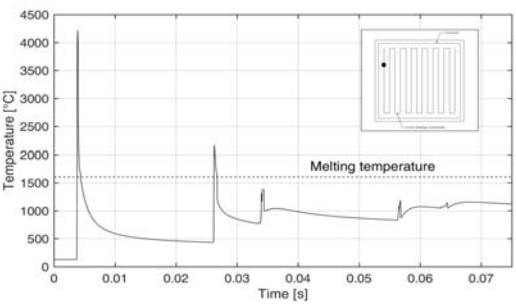
Dynamic mesh refinement

Constant mesh

Results – *thermal behaviour of molten pool*



Because of the high number of laser spots the simulation must be applied only to a small portion of the powder bed. Only one layer is considered and the scanning strategy adopted by the laser is the meander path. In order to gather information about the thermal field evolution into the bed powder, a probe element is chosen on the surface and the related temperatures are saved at each cycle. The small window in the graph shows the meandering path. The black point along meandering path represents the probe that the temperature graph refers to.



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