Faster, Better Metal and Polymeric Parts with Additive Manufacturing using Simulation

Additive Manufacturing Process Simulation for "First Time Right"

Luca Sironi – Sr. Account Manager
Alberto Faraboschi – Application Engineer

April 06, 2017
Experience in Simulation for over 50 years

1962 JFK's speech
1963 MacNeal Schwendler Corporation Founded
1965 NASA Contracts MSC to develop NASTRAN
1969 Man Lands on Moon
1971 First Commercial Version of NASTRAN
1972 First Shipment of Marc
1973 MSC goes Global
1977 Patran Founded
1980 Auto Industry adopts FEA Technology
1987 NASA utilizes MSC Nastran for structural analysis of the International Space Station (ISS) - NASA
1994 MSC Acquires PDA (pre/post processing)
1999 MSC Acquires Marc (nonlinear FEA)
2002 MSC Acquires MDI (mechanical dynamics)
2011 MSC Acquires FFT (acoustics)
2012 MSC Acquires e-Xstream engineering (materials)
2014 MSC Apex Simulation reinvented
2015 MSC Acquires Simufact (forming and welding simulation)
2016 MSC Acquires Cradle (CFD)
MSC Strategy
Simulating the Complete Product Engineering Process

Materials → Fabrication → Parts → Assembly → Systems
User Challenges / Pain Points

- **Distortion**
  - Recalculate initial shape, so that distortion can be compensated
  - Minimize too high distortion in the height (z)
  - Stiffness in z-direction due to support structures

- **Residual Stresses**
  - Cause Cracking
Additive manufacturing: Material engineering

Input

[Matrix properties]

[Filler properties]

[Percentage]

RVE Generator

Output

Homogenization to perform Finite Element modeling of realistic Representative Volume Elements (RVE)
Digimat can help engineering “Digital Materials”

Example: Discrete Digital Material – Rigid & Rubbery

- Black rubbery material (Tango +)
- White rigid material (Vero white)
- Grey scale & Shore hardness scale

Source: Multi-Material Voxel based 3D Printing. A New Horizon in Composition Freedom, Oren Zoran (Stratasys), DigimatUM16, oct 2016
Additive Manufacturing Engineering

Design Methodology

Material Engineering

Process evaluation
Micro scale Approach

**IMPLEMENTATION**
- Transient FE-method
- Utilizing microstructure models
- Based on real scanning path

**RESULTS**
- Temperature history
- Mechanical Properties
- Stress
- Distortion
- Microstructure

**BENEFIT**
- Highest level on physical information
- Considering temperature dependencies
- Allows basic parameter studies
Meso Scale Approach

**IMPLEMENTATION**

- Segment-wise utilization of *inherent strain* method or *thermal cycle* method
- Layer and pattern based

**RESULTS**

- Mechanical properties
- Residual stress distribution
- Part distortion
- Temperature distribution

**BENEFIT**

- Reasonably fast in computational time
- More physical information
- Considering temperature dependencies
- Decoupled or fully-coupled analysis
Macro Scale Approach

**IMPLEMENTATION**
- Voxel technique up to millions of elements
- Inherent strain method
- Layer based
- Automatic support structure generation

**RESULTS**
- Residual stress distribution
- Part distortion

**BENEFIT**
- Extremely fast in computational time
- Simple tests to determine inherent strain parameters (Cantilever Test)

4 cores @ 2.6 GHz standard workstation: 5 minutes
Inherent Strain Method: Some Background

- Heating and cooling down introduce strain in the build
- These strains are depending on the scanning direction, material etc.
- Inherent strain is a generic name given to such nonelastic strains as thermal expansion, phase transformation, initial strains, plastic strains and misfit strains.
- The inherent strain values are defined for each layer are used to calculate the residual stresses and thus the distortion of the part
- One approach to get the parameters is to estimate them based on material properties and process parameters
- Simufact Additive uses the „Cantilever Test“ results to get a better prediction of the inherent strain values
Simufact Inherent Strain Procedure

- Iterative Procedure
- Enter Displacements
- Obtain Inherent strains
GUI – Metal AM Simulation

Graphical User Interface

- Completely new developed
- Intuitively, User friendly, Ease of Use
- Clean Surface
- Quickly productive
- Fast modeling
- Import CAD Part & Supports
- Internal Supports Generation
- Automatic meshing of (almost) any shape
- Workflow orientated
Complex parts
Engineering of AM Materials

FDM/SLS Process Modeling

Printed Part performance
MaterialCenter Eco System

- MaterialCenter is a Material Lifecycle Management (MLM) system
- **Scope:** From Manufacturing *to* Physical & Virtual Test *to* CAE, PDM/PLM
- **Capabilities:**
  - Full material traceability
  - Best in class Excel integration
  - Data & process management for physical & virtual - manufacturing & test
  - Automation of Materials Process
  - Open flexible schema to characterize Manufacturing, Material & Test at any level
  - Export to Solvers & Deep client integration
  - Work flow & Approval flow
  - Built in, direct Mvision integration
Thank You

luca.sironi@mscsoftware.com

www.mscsoftware.com/it
www.facebook.com/mscsoftwareitalia
www.linkedin.com/company/msc-software
www.youtube.com/user/simulattemore