COMPUTER AIDED TECHNOLOGIES FOR ADDITIVE MANUFACTURING

OMiLAB4FoF: An environment to design and develop modelling methods for the Factory of the Future

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http://www.CAxman.eu
09/2015-08/2018.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 680448.
Additive Manufacturing (AM) involves many competences

State-of-the-art CAD targets subtractive manufacturing and is B-rep based*

B-rep describes volumes by their inner and outer hulls as patchworks of (trimmed) elementary and NURBS surfaces.

Geometry input to AM is most often a triangulation in the STL-format. A new option is the slightly richer AMF format.

Neither STL nor AMF can exactly reproduce CAD descriptions, and CAD models have to be approximated. This is similar to printers before Postscript was introduced.

* B-rep – Boundary structures developed in the 1980s, and standardized in STEP (ISO 10303) in the 1990s
Very little interoperability with AM – One way information flow

To update a CAD-model from AM Process Planning is very complex

Support structures are today designed as part of process planning

Design of support structures, complex inner structures and anisotropic material very limited in current CAD

The STL-wall
Input to AM Process Planning is a tessellation of the CAD-geometry

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Interoperability essential in future CAX-technologies for AM

Update of design model after Process Planning should be simple

Support structures should be addressed already during design

Analysis based design

Material technology

AM Process Planning

Complex inner structures should be represented in the design model

Anisotropic material should be represented in the design model

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Immediate challenges to CAx* for AM

- Scale
- Descriptions
- Methods
- Analysis
- Abstractions
- Semantics

Current representations cannot handle complexity of microstructure in conjunction with a larger structure.

* CAx – Computer Aided Technologies

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Immediate challenges to CAx* for AM

- Methods
- Analysis
Immediate challenges to CAx* for AM

- Methods
- Production
State-of-the-art information flow: CAD to Finite Elements and Additive Manufacturing

- Meshing and STL conversion reduce shape quality
- Updating CAD-models from modified mesh/STL a challenge
- Different areas of competences with weak information interoperability
CAxMan vision: Interoperability between CAD, FEA and AM

- CAD extended with novel 3-variate isogeometric analysis extensions in ISO-103030 (STEP)
- Isogeometric Analysis or FEA harvesting 3-variate CAD
- AM extensions to STEP Part 242 Edition 2
Complex to extend current CAD-systems with novel representations

• The recent Isogeometric extensions of STEP* (ISO 10303) add 3-variate (mathematical volumetric) representations to STEP in the shape of
  • Locally Refined B-splines (Spline space approach to local refinement of splines, guaranteeing nested spline spaces)
  • T-splines (control mesh/algorithmic approach to local refinement of splines)
• Current CAD-systems are based on B-reps a 2-variate (mathematical surface) representation and cannot be expected to include the new possibilities in foreseeable future (legacy of models and software)

* Proposed by fp7 FoF STREP TERRIFIC (2011-2014)
The title of the H2020 FoF* CAxMan, is the title of this talk

The ambition of CAxMan is to break down the STL wall by:

• Providing a 3-variate design representation suited for analysis based design supporting complex inner structures, support structures, and variable/anisotropic material
  • Locally Refined Splines (Recent ISO 10303 STEP extension)
  • Subdivision volumes for design of inner voids and cavities
  • Design models IGA compatible, can be harvested for FEM

• Design interoperable with process planning and thermal simulation of AM

• Provide a Cloud Platform and Cloud services in the form of workflows of applications and services addressing analysis based design, process planning and thermal simulation

• Provide an ecosystem of algorithms for AM (Open Software)

• Contribute to standardization on AM (ISO 10303 –STEP)

* FoF – Factories of the Future an EU Public Private Partnership (PPP)
CAxMan provides results as Cloud services

The Cloud facilitates direct distribution of new services, applications and workflows directly to the end user (e.g., SMEs) without software installation on the web browser of client device (VCN an option as well).

- CAxMan builds on the fp7 IP CloudFlow (2013-2017) and its Cloud infrastructure, and selected services, applications and workflows from CloudFlow such as Product Lifecycle Management (PLM)
- CloudFlow addresses HPC Cloud Services for small and medium sized enterprises and includes 6 internal and 14 external experiments selected after two rounds of Open Calls.
  - Originally 11 partners
  - Extended to 46 partners following external calls for new experiments in 2014 and 2015
  - Total EU-funding: 6.6 M€ (2M€ for the external calls)
  - [www.cloudflow.eu](http://www.cloudflow.eu)
CAxMan Use Case partners

Injection molds cooling system (France)

Special gear box (Italy)

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Horizon 2020 Grant Agreement Number 680448
OVERALL CAxMan IDEA

Focus on better design of support structures for:
- Minimizing thermal deformations
- Reducing use of powder

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CAxMan does not address all aspects

- Topology optimization
- Analysis based design for AM
- AM process planning
- AM material aspects
  - Metal
  - Polymer
  - ....

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CAXMan - Facts

• Duration: September 1, 2015 – August 31, 2018
• EU-contribution: 7,143,300€
• Effort: 748 Person Months
• Coordinator: SINTEF, Norway (Tor Dokken)
• Partners from
  • Austria: 1
  • France: 2
  • Germany: 2
  • Italy: 2
  • Norway: 3
  • Slovenia: 1
  • Spain: 2
Partners – European Dimension
Impressions of ADOxx.org

ADOxx – OMiLAB
Summer School, Book, ...

ADOxx.org at Conferences

John A. Zachmann will come to OMiLAB Summer School

ADOxx – Trainings

3rd Party Communities talk about ADOxx

Prof. Lee, Chonbuk University: „Best Paper with ADOxx solution“

EU Project collaboration on ADOxx.org
THANK YOU FOR YOUR ATTENTION!

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