MULTI PHYSICS SIMULATION IN MANUFACTURING

A. Junk CADFEM GmbH
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- Multi Physics in Manufacturing
- Manufacturing example: Residual Stresses in an Induction Hardened Roll
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Manufacturing

Multi Physics in Manufacturing

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Set up

Conclusions
MULTI PHYSICS SIMULATION IN MANUFACTURING

Manufacturing

Product engineering
Design

Product
Part/ Assembly/

Life

Recycling

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MULTI PHYSICS SIMULATION IN MANUFACTURING

Classical manufacturing

- Forming
- Cutting
- Material property shifting
- Joining
- Master forming
- Coating

Manufacturing
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Classical manufacturing processes

- Based on long term experience

- A lot of trial and error

- Evolutionary, empirical processes

- By the time, the process is running, we know what doesn’t work, but often we don’t know why it works

- When the process is running, it is the optimal process? Often we do not know it!
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Classical manufacturing processes, challenges

- Shortening of time for product design
- Shortening of time for the development of the manufacturing processes
- Contraction of product lifetime, with a reduction of the refunding time of the development costs
- New Materials with new characteristics but without manufacturing know how
- New designs with really new manufacturing processes without experience
- Looking for the optimal process (Costs: material, energy, time, quality,...)
- Loss of know how sources
Challenges of manufacturing processes: methods of resolution

- Expansion of manufacturing development division
  
  Short time: cost increasing  
  Long time: cost increasing

- Outsourcing of manufacturing development division
  
  Short time: cost reduction  
  Long time: loss of manufacturing know how followed by cost increasing  
  ...loss of the market

- Intensification of manufacturing development
  
  Short time: cost increasing  
  Long time: increasing of manufacturing know how followed by cost reduction
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Intensification of manufacturing processes

- Increasing the understanding of the processes
- Saving of manufacturing know how
- Developing of new processes, based on higher process understanding

...the road is...

...Simulation of the manufacturing processes!

- The simulation models describe the process and the valid process window
- In the simulation model, the process know how is saved
- The simulation provide an insight into the manufacturing process. With this insight, it is possible to design new, better processes
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Multi Physics in Manufacturing

Technical Mechanics
Optics
Electrodynamics
Plasma Physics
Thermodynamics
Acoustics
Fluid Mechanics
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Manufacturing example: Residual Stresses in an Induction Hardened Roll*

Finishing of a calender roll

Balancing of a roll

*) CADFEM Users’ Meeting 2005: „Simulation der Eigenspannungen in einer induktionsgehärteten Walze“; Bonn, 10 Nov. 2005
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Manufacturing example: Residual Stresses in an Induction Hardened Roll*

Induction heating…

…and cooling of a roll

*) CADFEM Users’ Meeting 2005: „Simulation der Eigenspannungen in einer induktionsgehärteten Walze“; Bonn, 10 Nov. 2005
Manufacturing example: Residual Stresses in an Induction Hardened Roll

Spray cooling
V = 35 m³/h, 30°C

Surface temperature
App. 980°C

Inductor
P ≈ 600 kW

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Manufacturing example: Residual Stresses in an Induction Hardened Roll

Multi Physics in Manufacturing

- Technical Mechanics
- Thermodynamics
- Fluid Mechanics
- Plasma Physics
- Electrodynamics
- Acoustics
- Optics
Manufacturing example: Residual Stresses in an Induction Hardened Roll

Multi physics of the process:

- Magnetic field
  - MURX (T)
  - Current losses/heat source terms
  - HF (T)
  - Youngs modulus (T)
- Electric field
  - RSVX (T)
- Theral field
  - Temp (x,y,t)
  - DENS (T)
  - C (T)
  - KXX (T)
- Microstructure
  - Thermal strain
  - Structural mechanics

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Residual stresses, measured …

... and calculated residual stresses

*) CADFEM Users’ Meeting 2005: „Simulation der Eigenspannungen in einer induktionsgehärteten Walze“; Bonn, 10 Nov. 2005
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CLASSIC, Setup and handling

- A lot of hand made actions
- User defined and organized file system
- Hand made connection of the different physics

- The need of a lot of program intern know how
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WORKBENCH 2, Setup and handling
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Conclusions

- Simulation of manufacturing processes save costs
- Simulation gives more understanding of the processes
- With the simulation, the process know how is saved
- With simulation, you can design new processes

- ANSYS has powerful multi physics capabilities
- Long time experience with multi physics process simulation
- A wide range of physics can be coupled
  - Mechanics, Fluid, Thermal, Electrical, Acoustic,…

- WORKBENCH 2, never before multi physics simulation were so easy
- New Generation of multi physics simulation platform
- Platform for simulation data management
- Platform for “save” of simulation know how
- Open architecture to “include” 3rd party products
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