“Simulation for process and die design in forging”

Presented by

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Korea Metal Week 2007
Seoul, 26.10.2007
“Simulation for process and die design in forging”

History and fields of business of CPM

Industrial applications of Simulation

Conclusion

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History and fields of business of CPM

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History of CPM

CPM was founded in 1987 in Aachen, Germany as a spin-off of the University of Technology of Aachen – one of the biggest and best in its field in Europe.

CPM worked on software solutions in the field of metal forming in general.

In 1990 CPM moved to Herzogenrath, Germany and changed its focus to technology and simulation in forging.

CPM provides engineering service to forging companies worldwide.
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Business of

CPM Gesellschaft für Computeranwendung, Prozeß- und Materialtechnik mbH
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Fields of Business

- Consultancy in cold, warm and hot forging
- R&D in public funded and bilateral projects
- Simulation as service
- Development of simulation systems
- Material-data (incl. investigation in mat.-data)
- Distribution of tooling etc.
• Consultancy in cold, warm and hot forging

Example: Spark Plug

Problem: Cracking because of wrong adjustment
eesy-2-form V2.8lx (2D AXISYMMETR.)  LIC.NO. ORIG36  12.05.2003  00.14
INFO1:  Nedschroef  INFO2:  spark-plug

ned9a41e.fin

X-coordinate in mm

Y-coordinate in mm

Tool 1

Tool 2

120°C
R&D in public funded and bilateral projects

Verbesserte Verfahren der Gewindeherstellung

3D Simulation

Forgenet

Ecologically Optimised Cold Forging

Yield Stress Strain Curves

Modeling of Metal forming based on microstructure for micro-alloyed steels in multi-station forging operations

Aluminum parts for Automotive applications
Development of simulation systems

Example of a 3D application
Development of simulation systems

Example of a 3D application
Development of simulation systems

Example of a 3D application
R&D in public funded and bilateral projects: Forgenet
R&D in public funded and bilateral projects

Innovative processes in producing screws (Aluminium) (MWMTV-NRW)
• **Tasks to solve:**
  - Garde of aluminium
  - History before forging (casting, drawing, heat-treatment)
  - Forging technology
  - Progression
  - Tooling
  - Tool Coating
  - Lubrification
  - Handeling
  - Heat-treatment
  - Coating
R&D in public funded and bilateral projects

Ecologically Optimized Cold Forging

- no phosphate
- coated wire
- new oils
- tool surface treatment
- ....
R&D in public funded and bilateral projects

Modeling of Metal forming based on microstructure for micro-alloyed steels in multi-station forging operations
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Development of simulation software

• Eesy-2-form

• Eesy-form
• Data centre for Material data
• Investigation in stress-strain curves
• Distribution of material data (>150 material)
• Consultancy in application of stress-strain curves and other material data
• Contacts to further recourses
Distribution of Tooling/etc.

- Tooling of TNP for Cold-forging, Korea
- Standard tools und Specials
- Special punches (6-lobe,...), Korea
- Dosing-systems of Serte, Italy
- Tooling of Eurotool, Italy
- Tooling of “CG”, Taiwan
- Export of special tooling from Germany
- Inspection machines from Italy
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Distribution of Tooling/etc.
Distribution of Tooling/etc.
Partners

- India King Impex, India
- Chang Chi Metal, Taiwan
- Chang Chi Metal + partners, China
- Chierichetti, Italy
- Consultec, Brazil
- COMTESA, Spain
- Jin-A Commerce, Korea
- Extrusion Process System, Singapore, Malaysia, Ind.
- Memsan, Turkey
- Jury Lavrinenko, Russia
- Johnson Machines and Tooling, UK + Ireland
- Nedschroef, Belgium + Worldwide
Spectrum of clients

- Companies producing cold, warm and hot forged parts
- Universities

Companies in the range of small and medium size enterprises up to large companies in international business
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Industrial applications of Simulation

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Principle of Process Design Work

Product drawing

Empirical process design

Testing on the machine

Re-design

Development cycle

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This development cycle is very cost intensive and covers a lot of uncertainties.

Testing on the machine

Re-design

Development cycle
Besides reducing the costs of the product development, simulation can help:

- To develop specific product properties
- To analyze the product application
- To train production and engineering personnel
- To explain production tasks to a customer during common development
- To build up technological “know why”
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Examples of application
Examples of application

Tool failure in production of a valve spring retainer
Folding of material
Failure of punch because of contact problems
Cracking of a screw head due to tangential stress
Die failure
Die design
Forming station with spring loaded die
Difficult tool design for a combined forward and backward extrusion
Microstructure prediction in forging
Tool failure in production of a valve spring retainer
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Tool failure in production of a valve spring retainer

- Searching for Failure of punch High stresses!
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Tool failure in production of a valve spring retainer
Avoiding of failures

Failure of a punch

wrong pre-form design!
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Folding of material
Folding of material

Folding / Underfilling on an inner race
Folding of material

Folding / Underfilling on an inner race
Folding of material

Folding / Underfilling
on an inner race
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Folding of material

Folding / Underfilling on an inner race
Folding of material

Folding / Underfilling on an inner race
Folding of material

Folding at nut in
- Surface and
- Thread area
Folding of material

- Folding at nut in Surface and
- Thread area
Failure of punch because of contact problems

Flansh nut 2nd. Station
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Failure of punch because of contact problems

Flansh nut 2nd. Station

Non sufficient contact between punch and material!
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Failure of punch because of contact problems

Flansh nut 2nd. Station

inhomogeneous stress situation!
Failure of a punch in another nut making process due to the same reason.
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Cracking of a screw head do to tangential stress
Cracking of a screw head due to tangential stress

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Die failure
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Die failure
Die failure

**Principle of Die Design**

\[ \sigma_{\text{tan}}: \text{critical for axial crack} \]

\[ \sigma_y: \text{critical for horizontal crack} \]
Die failure

Principle of Die Design

\( \sigma_y: \) critical for horizontal crack

horizontal split of the insert

Horizontal splitting
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Die failure

Principle of Die Design

$\sigma_{\tan}$: critical for axial crack

$\sigma_p$: Pre-stressing of the insert
Avoiding of failures (elastic analysis of the insert with FEM)
Splitting the die to avoid too high axial stresses
Die design

Pre-straining of dies to avoid axial die breakage
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Calculation of Die Layout

Die design
The stress distribution in an insert with pre straining optimisation.
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Punch die to form torx recesses.
After systematic optimization such a punch produces more than 2,000,000 parts!
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation
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Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Initial position
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Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Die starting to slide
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Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Die sliding
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Final position
Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

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Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

Initial position
Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

intermediate position
Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

Final position
Microstructure prediction in forging

Initial blank

Final shape
Microstructure prediction in forging

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Distribution of strain

Fibre distribution
Microstructure prediction in forging

- Grain size
- degree of re-cristallisation
- dynamic re-crist. fraction
- static re-crist. fraction
- grain-groth
- timing and recovering

Aims of simulation

Gain size distribution
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Conclusion

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Conclusion

Most of the daily problems in design of a metal forming process can be supported by today simulation technology.

Some special applications need further development still.

Simulation is generally established as a design tool.

Hurry up to not miss the train .. But choose your simulation partner carefully …… he has to be expert in forging as well!
Thank you for your attention!

You are most welcome to contact CPM or Jin-A.

Like this bird knocking at my door at a Hotel in China in the early morning......

I do not know whether he wanted support or knowledge or simulation....