INDTECH2018
Innovative industries for smart growth

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Vienna, Austria

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PILLAR 1

Session 1.5

The role of creativity and new enabling technologies for efficient manufacturing and automation

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Federal Ministry Republic of Austria Transport, Innovation and Technology
eu2018.at
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 767162.

Motivation

The 21st century is considered to be knowledge based.

Creativity, looking for opportunities, mental agility, new ideas, design thinking, risk management as well as digitization will influence our daily life, our orientation to stakeholders and future innovations in production, services and economic success.

Discover the *value of human capital*:

Σ education + creativity + accum. work experience

and support them by

- Creation of continuous learning opportunities
- Promotion of inquiry and dialogue
- Motivation for collective visions
- Establishment of a learning organization etc.

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Success factors for 21st Century Enterprises

- Have a clear vision, which is understood by everybody
- Be open-minded for any new technology
- Knowledge-based companies establish intangible assets
- Make use of digitization for business and for production
- Recruit only the best people, with the right base skills
- Do those job, you know best and love
- Try to develop high-tech products and no commodity
- Communicate to your team and to your customers
- Keep the employee motivation at a high level
- Train your staff and develop an international network

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About the role of new enabling technologies

A permanent monitoring of up-coming enabling technologies is quite essential to improve manufacturing and products.

Enabling technology	Application	Benefits
Sensor technologies	Process control	higher productivity
Simulation software	Domain-specific	Parameter optimization
Data analysis methods	Data mining	Find hidden information
Materials models	Microstructural evolution	Prediction of grain size, mechan.props
Novel NDT techniques	Quality assurance	Failure detection
Physical modelling	R&D	for upscaling to reality
Roboter	automatic handling	Saving of man power
Computer hardware	Process control, real time data aquis.	Storage, retrieval and evaluation of data
AI and Neural Networks	Automatic control & decision making	Pattern and speech recognition, support
Cyber Physical Systems	Embedded Model-based system	Knowledge based prediction of system behaviour

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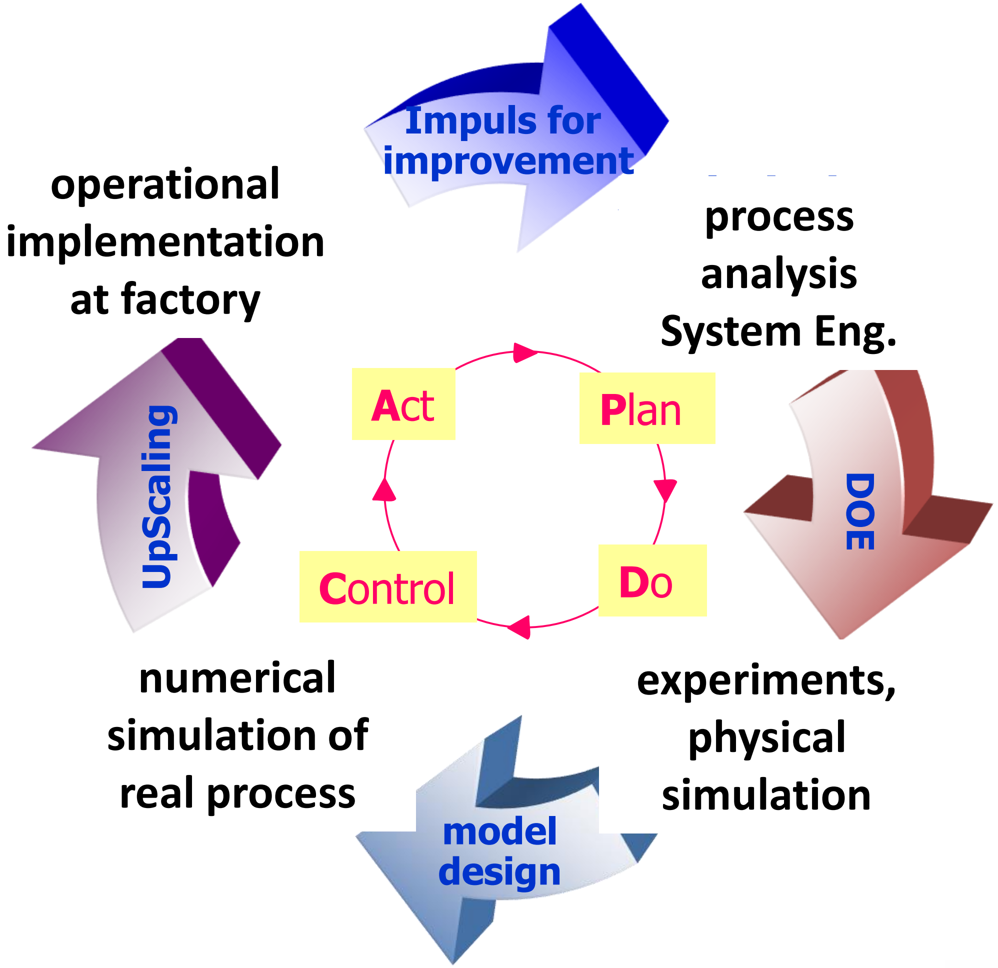
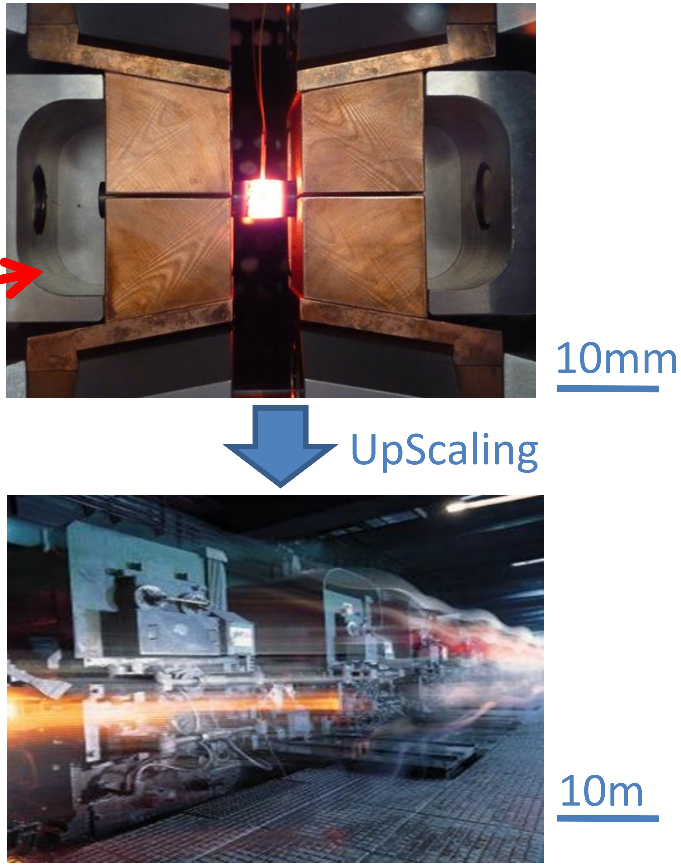
Process Analysis → Experiment → Simulation → Implementation



Physical simulation (Gleeble)



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Data-based learning versus Physical Modelling (CPS)

Data-based learning	Physical modelling
Pros:	Pros:
- fast non-supervised learning - applicable without deep understanding - statistical analysis (t-statistics) - ready to use software available - easy to apply	- physical based models are more accurate - full understanding of the underlying phenomena and more precise actions can be taken - model refinements are always possible - use in form of an inline model is quite powerful
Cons:	Cons:
- trustable data sets necessary - physical interpretation difficult - no extrapolation to wider ranges - mainly linearized effect description	- time-consuming model development - short-cuts necessary for real-time applications - lot of specific data have to be measured for model input

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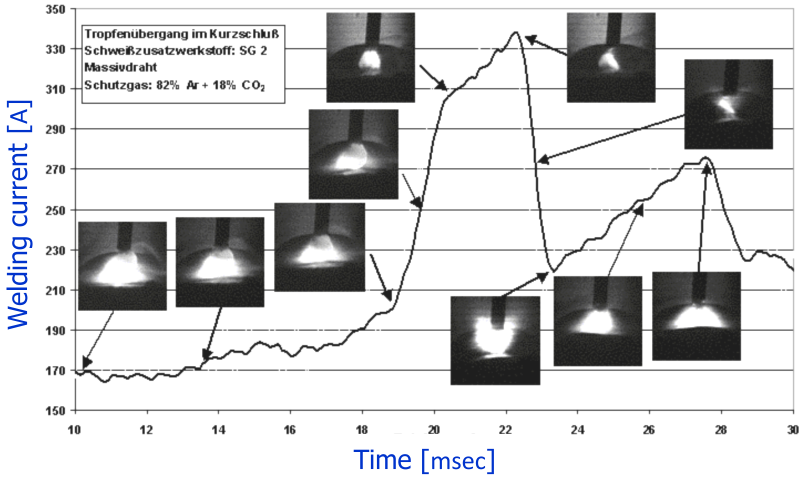
Deep Learning using Fast Fourier Transformation (= data-driven analysis)

Example on welding monitoring

Data Aquisition



Data Analysis

Auswertung:

$jmax := 0$ $\quad Fmax := \max(|cn|)$ $\quad Max\_Ampl := Fmax \cdot \frac{2}{\sqrt{Nsamples}}$ $\quad Max\_Ampl = 9.673$

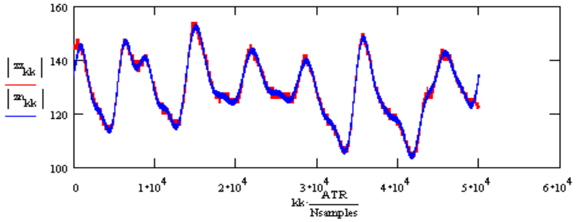
$jjmax_{jj} := \text{if}(|cn_{jj}| < Fmax, 0, jj)$ $\quad jmax := \max(jjmax) \cdot \frac{ATR}{Nsamples}$ $\quad \max(jjmax) = 7$

$tp := \frac{1000}{jmax}$

$jmax = 85.472$ [Hz] = **typische Tropfenfrequenz**

$tp = 11.7$ [ms] = **typische Tropfenübergangszeit**

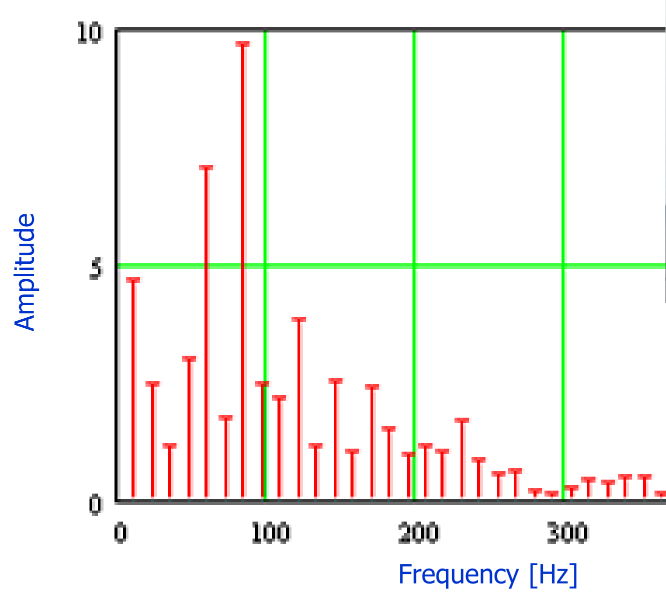
Rücktransformation:

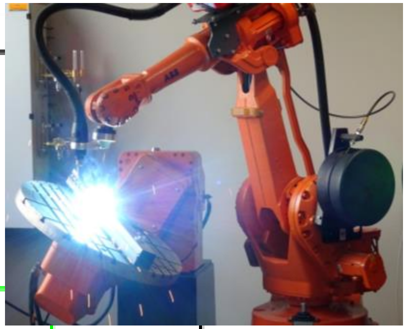


FACIT: Real-data acquisition combined with data analytics gives a continuous quality control and more insight into the process phenomena.

Here, droplet transfer rate during welding.

Result





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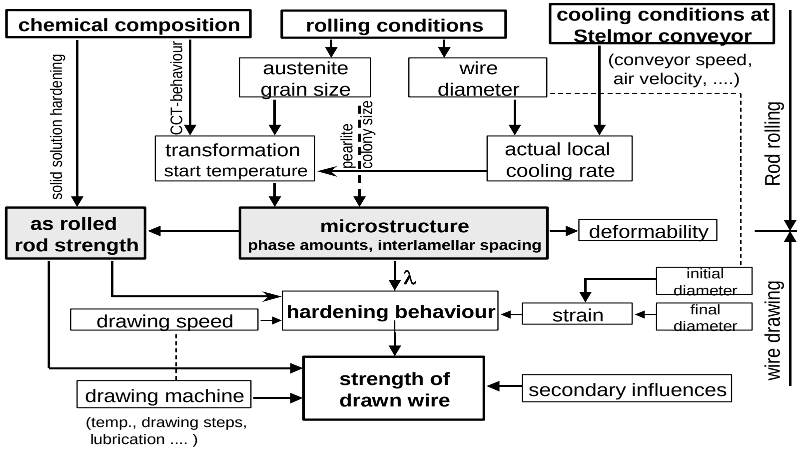
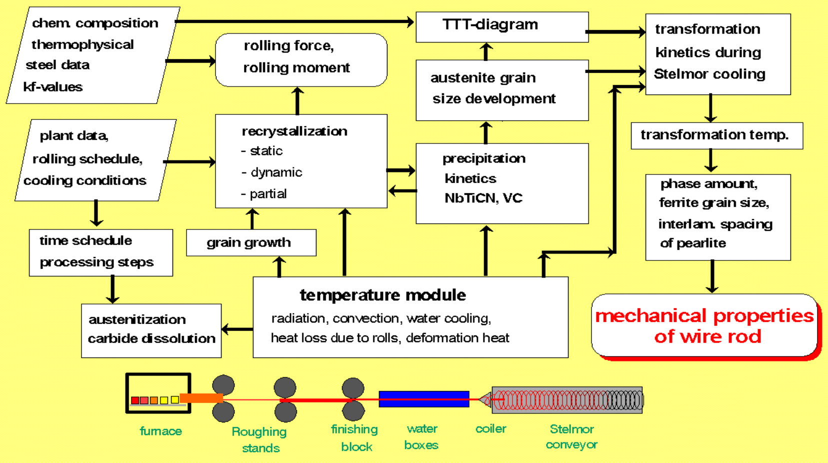
Model development for thermo-mechanical controlled rolling of steel wires

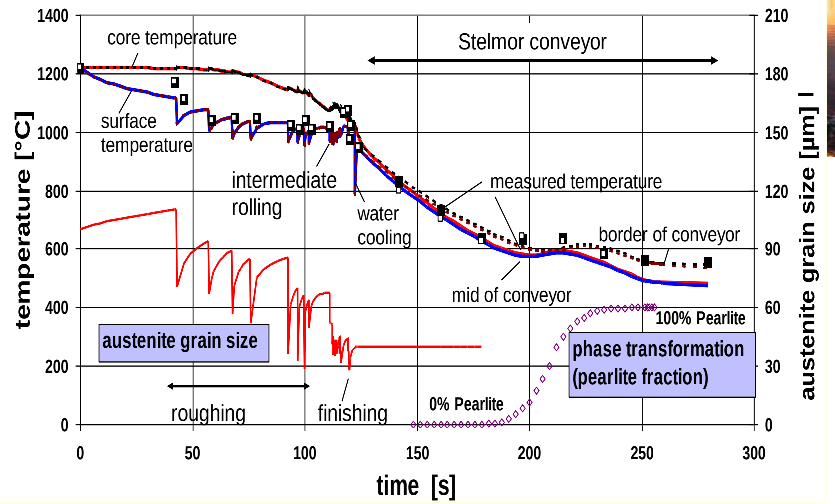
1. Analysis of influencing parameters



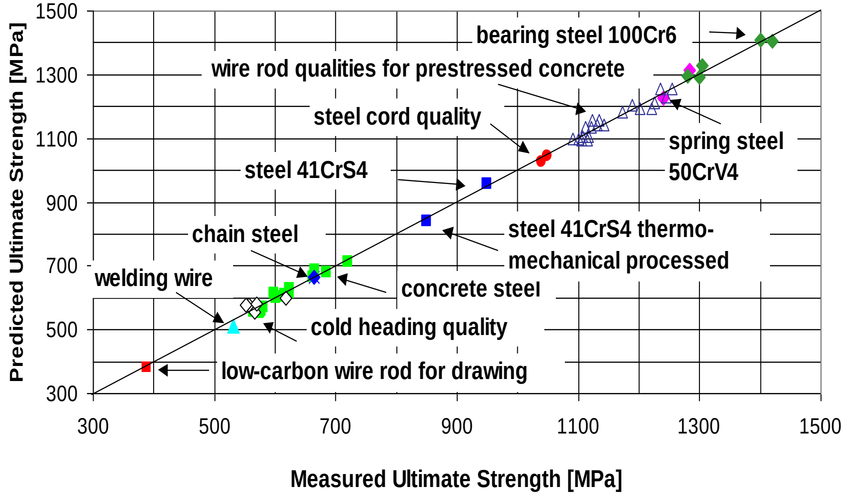
2. Microstructural based process model



3. Prediction of thermal history and microstructure



4. Prediction of mechanical properties of steel wires



But, how can we find new technologies or products ?

New developments need primarily creative people ! Phantasy is sometimes more important than knowledge!

Inner motivation

What is really important to you? What‘s dissatisfying you? Where are the opportunities? Where is the real need? Create for its own sake.

Looking for opportunities

Where‘s the main chance to do something new? How can you use knowledge from other branches? Rely on physical understanding.

Mental agility

Think in new directions, from new angles, with new perspectives. Create as many ideas as possible. Look at the problem differently. Exaggerate your ideas. Are there analogies in other areas?

Design thinking

Crave for simplicity. What patterns can you see around your idea? What can be rearranged?

Objectivity

Scrutinise and judge your ideas and ask others for their opinions. Listen to advice and test your ideas.

Managing risk

Where can you find courage? What is worrying you? What‘s the worst that could happen? How could you try out your ideas with min. risk.

David Perkins **Snowflake Model of Creativity**

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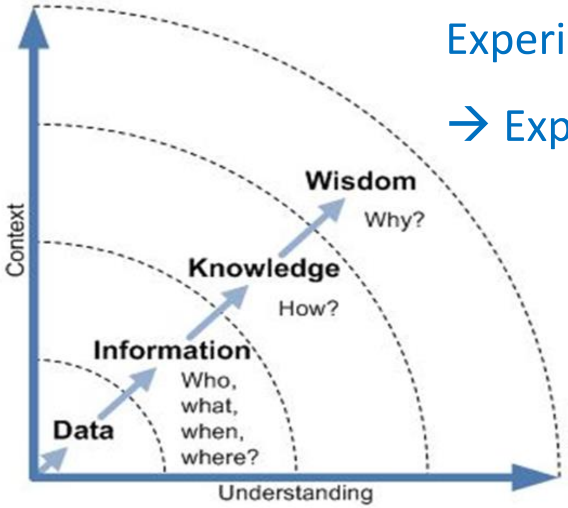
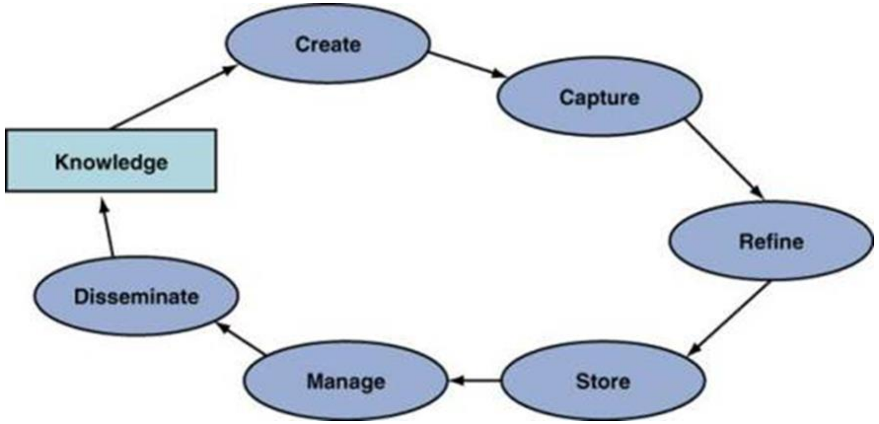
Knowledge Management and E-learning



Experienced people are rare or in an age of retirement

→ Expert systems, MOOCs, *WIKI-based systems* …



Information sources:

a) Books & Journals

b) Internal Reports

c) Brochures etc.

Content WIKI-rolling

CONTENT of WIKI-ROLLING:

1. Fundamentals of metal forming
2. Geometry and kinematics in the roll gap
3. Elementary rolling equations/models
4. Flow curves
5. Rolling force, torque and power
6. Spreading
7. Straightness and flatness
8. Hot rolling plants
9. Direct rolling (ESP,CSP,...
10. Cold rolling plants
11. Wire-rod rolling
12. Seamless tube rolling
13. Ring rolling
14. Heat balance
15. TMC-Rolling strategy
16. Microstructural control
17. Plant automation and control
18. Typical failures and malfunctions
19. Sensors and Inspection Systems
20. Maintenance
21. Domain experts

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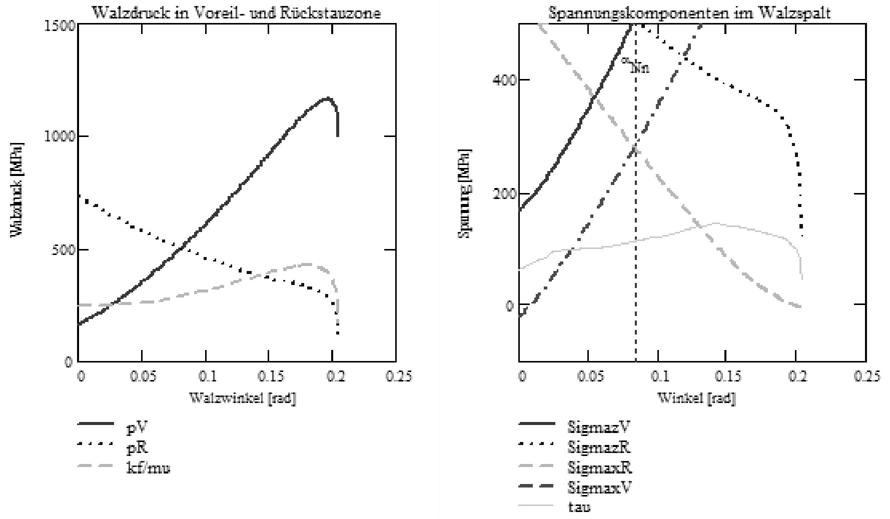
Model-based training systems for rolling and forging

Stresses and Forces in a rolling gap



Die Walzkraft und das Walzmoment werden wie folgt berechnet:

$$\alpha max := N \cdot d\alpha$$

$$F := \left[\left[\sum_{i=0}^{Nn-1} pV_{i,1} \cdot \cos\left(\alpha_i - \frac{\alpha max}{2}\right) - \tau_i \cdot \sin\left(\alpha_i - \frac{\alpha max}{2}\right)\right] + \left[\sum_{i=Nn}^{N} pR_{N-i,1} \cdot \cos\left(\alpha_i - \frac{\alpha max}{2}\right) + \tau_i \cdot \sin\left(\alpha_i - \frac{\alpha max}{2}\right)\right]\right] \cdot d\alpha \cdot r \cdot b \cdot 10^6$$

$F = 26.8186$ [MN]

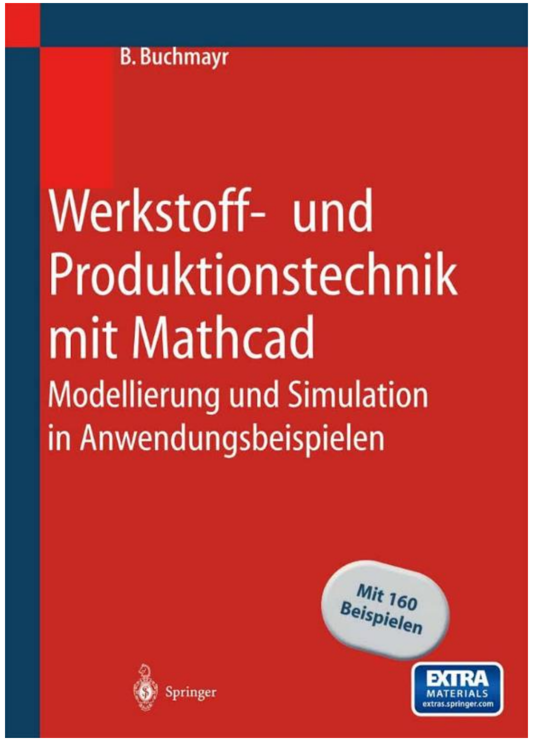
$$M := 2 \cdot r^2 \left(\sum_{i=Nn}^{N} \tau_i - \sum_{i=0}^{Nn-1} \tau_i\right) \cdot d\alpha \cdot b \cdot 10^9$$

$M = 1.9476$ [MN*m]

Umformwiderstand: $kw := \frac{F}{b \cdot ld \cdot 10^6}$

$kw = 366.8703$ [MPa]

Use of Computer Algebra Systems like MATLAB + Simulink, Mathcad etc.



example taken from chapter 6.5 „Flat rolling“

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What has to be done for future job-fitness of employees?

- We need not only to know how to use modern „things“, but also to understand and to make new developments.
- For that, we need a fast adoption of our whole education system and learning contents in every education level:
  - trainings on how to use and work with robotic systems
  - Enhanced knowledge in maths, physics, IT, IoT, electronics, …
  - Encourage young people to perform experiments (→ FabLab activities, digital factory)
  - Establish new study programs for Digitization
  - Build a new generation 5G mobile network within Europe
  - Create and foster new forms of learning (Wikis, MOOCs or SPOCs etc.)
  - Realise the educational order of public TV stations with quality
  - Make our population much more self-relient and more intelligent
  - Adopt new possibilities with high value for enhanced developments.
- We need to adjust our mind setting to new challenges.

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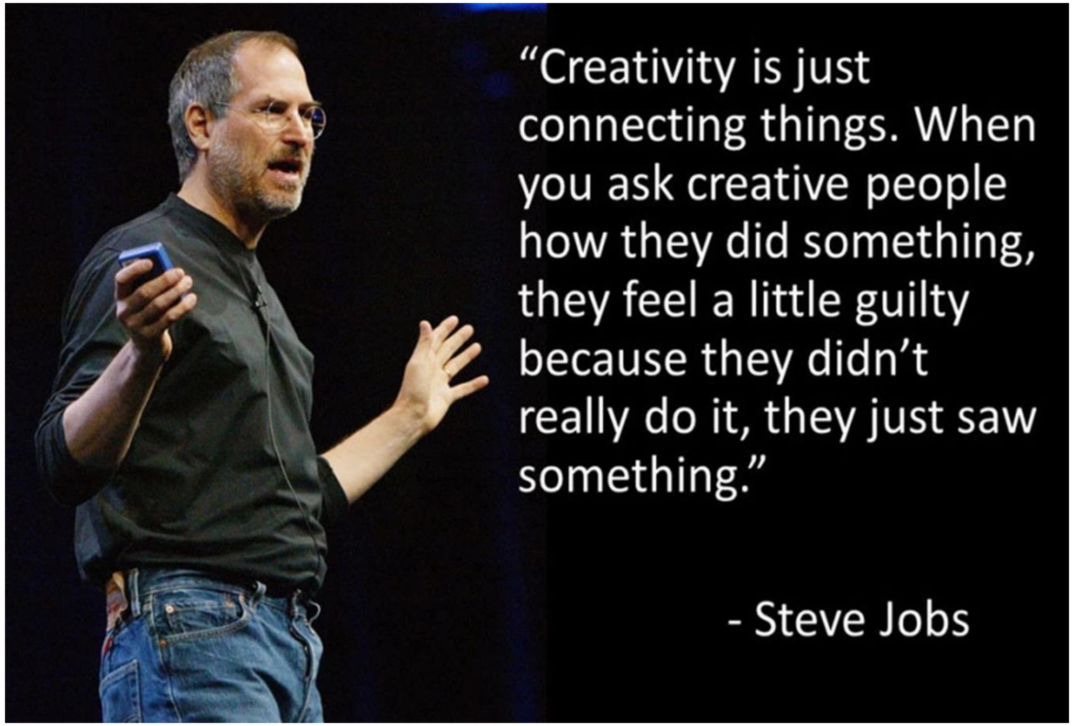
Conclusions

- Creativity is a key factor for new disruptive technologies.
- We need to do something differently rather than better.
- Systems Engineering and Design Thinking are stringent capabilities, which have to be trained at a high level.
- Enhance a “Culture of learning”.
- Adopt mindsets, which are essential to operational thinking, to modern times (explore, discover, develop, use digitalization).
- Use data-based deep learning methods to get out more information and understanding of manufacturing processes.
- Even better, use model-based systems (CPS), which cover fundamental physics or thermodynamics or other scientific fields, and which can be linked to more complex predictive systems.
- Foster universities in the development of modern, digitized curricula and to combine the virtual and real world.



We need real pioneers !

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