Aspects of Industry 4.0 at Steel Industry

Industry 4.0 Conference „The Digitalisation of the Metals Industry“, Ijmuiden, 9.5.2017

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› Private, **non-profit making** institute for **applied research** and development
› Short and medium term research driven by industrial needs
› Concentration to plant and process, no material development
› Steel industry, metals industry, process industry
› 100 employees, high academic degree, large industrial experience
Thematic orientation of BFI

- Energy efficiency
- Circular economy
- Process optimisation
- Deep understanding of production processes
- Industry 4.0 and Sensors
Interpretation of Industry 4.0 for Metals Industry
Four industrial revolutions!?

1. **First mechanical loom** 1784
   - 1st industrial revolution follows introduction of water- and steam-powered mechanical manufacturing

2. **2nd industrial revolution** 1870
   - First production line at Cincinnati slaughterhouses

3. **3rd industrial revolution** 1969
   - First programmable logic controller (PLC), Modicon 864
   - Uses electronics and IT to achieve further automation of manufacturing

4. **4th industrial revolution** today
   - Based on Cyber-Physical Systems

Source: Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Final report of the Industrie 4.0 Working Group, April 2013

Source: DFKI 2011

11.05.2017

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What is a “Cyber Physical System“?

„...merging of information processing with physical processes“

› IT-systems directly **embedded** in the technical process,
› Integration of processes among themselves by **information flows**,  
› **Interaction** of the technical process with its environment,  
› **Learning functions** to adapt technical processes and IT-systems.

- mechanics  
- electrics  
- automation  
- IT + Software  
- maintenance  
- HMI  
- identification

- identification  
- quality data  
- production history  
- process data  
- customer demands  
- algorithms  
- ....

Digital twins
Possible Cyber Physical Systems in Steel Industry

Assistance systems

Plant component

Production plant

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Aspects of Industry 4.0

› Horizontal integration

› End-to-end engineering

› Vertical integration and networked production systems
End-to-end engineering

plant

digital model of the plant

product design \hspace{1cm} production planning \hspace{1cm} production engineering \hspace{1cm} production \hspace{1cm} services

digital model of the product

product
Networked production (=horizontal integration inside company)

- Single plant as Cyber Physical Production System (CPPS, vertical integration)
- Intensive networking and communication of all plants (horizontal integration inside company)
- „Intelligent“ product with knowledge of its own quality and production history
- De-central instead of central solutions / self-organisation
Vision for steel industry

product data, process data, customer demands, order data, manufacturing specifications, production sequence, maintenance data, etc.

supply chain

product catalogue, product data, order data, logistic data, delivery times, etc.
Necessary (and realised) basic developments, some examples
Digital and processable information, here: manufacturing specifications

Manufacturing specification No. 4711 Rev. 7

Strip speed for customer 1 and customer 2

For customer 1 and customer 2 the material 0815 produced via process route P5 at the annealing line a final strip temperature of about 1234°C has to be ensured. For strips up to 0,9 mm thickness the speed is around 20 m/min, for thicker strips 15 m/min.

<table>
<thead>
<tr>
<th>Rule condition</th>
<th>Monitored process value</th>
<th>Allowed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material=0815 &amp; P=5 &amp; customer like [customer 1 or customer 2]</td>
<td>final strip temperature</td>
<td>1220 °C … 1250 °C</td>
</tr>
<tr>
<td>Material=0815 &amp; P=5 &amp; customer like [customer 1 or customer 2] &amp; thickness between 0,00 and 0,89</td>
<td>Strip speed</td>
<td>19 m/min … 21 m/min</td>
</tr>
<tr>
<td>Material=0815 &amp; P=5 &amp; customer like [customer 1 or customer 2] &amp; thickness larger then 0,90</td>
<td>Strip speed</td>
<td>14 m/min … 16 m/min</td>
</tr>
</tbody>
</table>
Semantic modelling of process chain

location

address

production site

plant

measurement

storage location

computer
database
tables
columns

DB column

DB table
tables
columns
Concept of „Smart Coil“

› **High resolution** and synchronised data
› Integration of **more-dimensional data** („spatial“) instead only 1D
› Furthermore text data, video-/audio-streams, data with gaps (**unstructured**)
› Possibility of fast processing and „**online“-usage“ of results
› Not only data but also **algorithms**

Big Data Analytics
Concept for data storage / data handling

- mySQL
- Oracle
- SQL
- MongoDB
- NoSQL
- MS_SQL
- CouchDB

technological solution

1-D continuous: strip tension, width, speed, etc

2-D continuous: thickness, flatness, temperature, coating layer

Event-based:
Surface defects, internal defects, Manual data
Realised applications
Decision support for material allocation

Rule based

Knowledge based

order customer application
manufacturing specifications
quality rules lower & upper limits

quality data process data

quality data process data

quality data process data

decision support

not ok

quality ok

taget?

not ok

quality?

rule treatment

environment

multi-criterial optim.

ok for allocation?

experience knowledge
Smart control of process chain
Smart Data for correlation of surface defects
Software agents to realise a virtual market place

one piece of product misses its target specifications…

… uses models to predict it’s future state…

… and negotiates at a virtual market place for an alternative order.
Self organised production

- QR-code
- Time stamp
- Temperature simulation
- Settings
- Pickling line
- Time for processing?
Ongoing developments
Prediction of product quality by Big Data and streaming technologies
Conclusions

› Industry 4.0 is not a revolution, it’s an **evolution**

› **Industry 4.0** is much more than **Digitalisation**

› Digitalisation is only **one part** of Industry 4.0

› Industry 4.0 is more a **paradigm / philosophy** than a technology

› For each industrial sector Industry 4.0 has to be interpreted **individually**