International Congress on Sustainable Manufacturing 2017

SmartAssembly – Benefits of I4.0 at the example of a smart workbench

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Agenda

- China 2025
  - China 2025 & Industry 4.0
  - Products

- Requirement Engineering

- SmartAssembly solution

- Benefit of Industry 4.0 features
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Power of Chinese Manufacturing

**28 Mio. cars**
No.1
Automotive manufacturing

**1.1 Mio. Machines***
No.1
Machine tools manufacturing

**1.4 bn. KW**
No.1
Power-generation Equipment manufacturing

**808 Mio. Ton**
No.1
Crude Steel manufacturing

**50 Mio. Ton**
No.1
Ship building

Remark:
All figures are 2016 officials from NBS
*total no. consists of 783K machine tool cutting and 318K machine tool forming.
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Industry 4.0 - the Enabler of ‘Made in China 2025’ | Strategy

3 Stages

2025
One of the strong global manufacturing power

2035
Mid-level among the strong manufacturing power

2045
Leading manufacturing power

2 Pillars

The 4 advantages

Market
Enterprises
Strategy
Talents

The 10 key sectors

New information technology
Numerical control tools
Aerospace equipment
High-tech ships
Railway equipment
Energy saving
New materials
Medical devices
Agricultural machinery
Power equipment

1 Goal

Manufacturing Transformation & Upgrading
= Industry 4.0

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### Market situation 2015
- Labor intensive industry with maturity between I2.0 and I3.0
- ‘Low variety, high batch’
- High ppm rates
- No connectivity
- High stock
- Extremely cost driven
- Fast and extremely volatile

### Success Factors China 2025
- Higher productivity
- Improve training and skillset labor work force
- ‘Higher variety, smaller batch’
- Quality improvement
- Real-time & preventive service
- Low inventory

### Project target
- Development of
  - A smart workbench
- For 18 types of hydraulic valves
- For the transition of the Chinese manufacturing 2015 → 2025
- Under consideration of the local market requirements
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Requirement Engineering

- Increased Productivity
- Efficient and flexible production system
- Connectivity with open standards
- People as key player
- 18 Types

Improved quality with reduced failure rate

Virtual representation in real time

Digital life-cycle management
Productivity
- Offline training program

Manufacturing concept
- Integration of 18 valve types

Connectivity
- PLC

Quality
- Pick2Light

Visualization
- Local App

Digitalization
- Local order management
SmartAssembly solution | 2016

**Productivity**
- MTM
- Ergonomic optimization

**Manufacturing concept**
- Value stream design

**Connectivity**
- Local network

**Quality**
- Quality control by camera
- Torque control

**Visualization**
- Real-time local data

**Digitalization**
- Data analysis
Productivity
- Sensor integration
- SmartSetup

Manufacturing concept
- Stock management

Connectivity
- Integration into SmartManufacturing network

Quality
- Hand tracking
- Worker feedback

Visualization
- Real-time data on ActiveCockpit

Digitalization
- Global order management

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**Productivity**
- Sensor integration
- SmartSetup

**Manufacturing concept**
- Stock management

**Connectivity**
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**Quality**
- Hand tracking
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**Visualization**
- Real-time data on ActiveCockpit

**Digitalization**
- Global order management
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Benefits of I4.0 | Test planning

- Input factors
  - Information gathering (Paper, Tablet)
  - Pick aid (Numbering, Pick-to-light)
  - Camera (off, on)
  - Number of valve types assembled (1, 3, 5)
  - Learning program (off, on)

- Response
  - Time (per assembly step, pick, information gathering, error, tightening gun, system)
  - Assembly errors
  - Video captured (2x)
  - Short survey

→ Fractional factorial design chosen
  - Reduction of required different experimental setups from 24 (full factorial design) to 12
  - 63 test persons attended (ø age 25.8 years; ø height 173.4 cm)
  - 10 valves per test person
Benefits of I4.0 | Flexibility

Learning Curve
- 1 type
- 3 types
- Learning curves as expected. Steep decrease in the first valves and stable times in the end
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Benefits of I4.0 | Productivity

Productivity increase

![Image showing productivity increase comparison between no industry 4.0 (I4.0) features and all industry 4.0 (I4.0) features.]

- **53% reduction**
- **38% reduction**

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**Graph:**
- Time [s] on the y-axis.
- Valve number on the x-axis.
- Lines and markers indicating different scenarios:
  - No I4.0 features
  - Pick-to-light only
  - All I4.0 features
  - Trend lines for each category.

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Benefits of I4.0 | Quality

Quality

V4 by valve number (errors)

V8 by valve number (errors)

48 % reduction

79 % reduction
Benefits of I4.0

**Summary**

**Productivity**
- Significant improvements for assembly time
- Increased flexibility in production order
- Quick setup of process modules for new tasks

**Digitalization**
- Global and centralized order management on ActiveCockpit
- Virtual description of manufacturing and assembly processes

**People as key player**
- Mastering complexity through improved ways of visualization and operation
- Individual integration of the employee in the work process

**Quality**
- Drastic reduction of assembly failures
- Worker feedback ensures continuous improvement and learning

**Virtualization**
- Seamless integration and processing of all data along the value stream
- Fast reaction times due to easy evaluation and optimization of scenarios

**Manufacturing concept**
- Reduced inventory due to virtual stock management
- Key performance improvements due to value stream design

**Connectivity**
- Guaranteed quality and reliability of real-time data
- Ad hoc connection of people, processes and machines
Thank you for your attention.