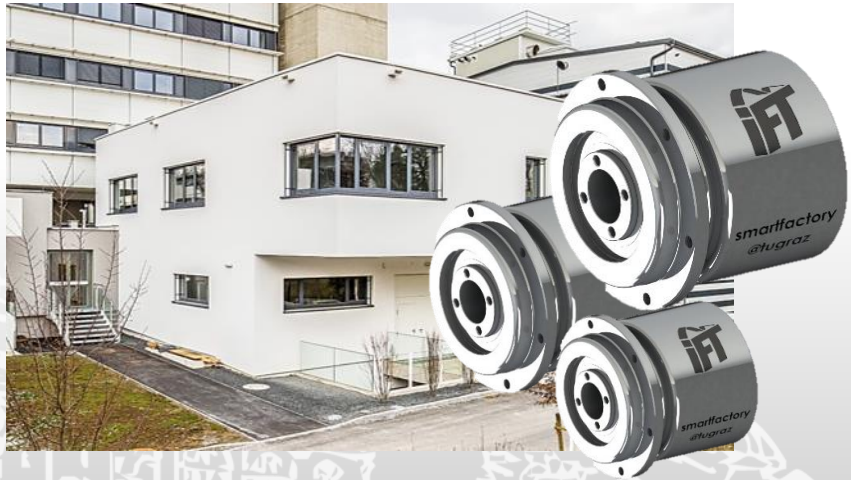


smartfactory@tugraz

LERNFABRIK FÜR AGILE UND DATENSICHERE FERTIGUNG

Digitalization for Batch Size One Production of Robot Gear Boxes – Realistic Scenario or Illusion

Prof. Franz Haas / Prof. Rudolf Pichler

12.07.2018

Agenda

- Introduction
- Industry 4.0 pilot factory: smartfactory@tugraz
- Case Study: robot smartgear
- Parametric design
- Workflow and factory concept
- Sensors and sensor networks as I4.0 enablers
  - Milling temperature
  - Electrical power
  - Grinding force
- Next steps and Conclusion

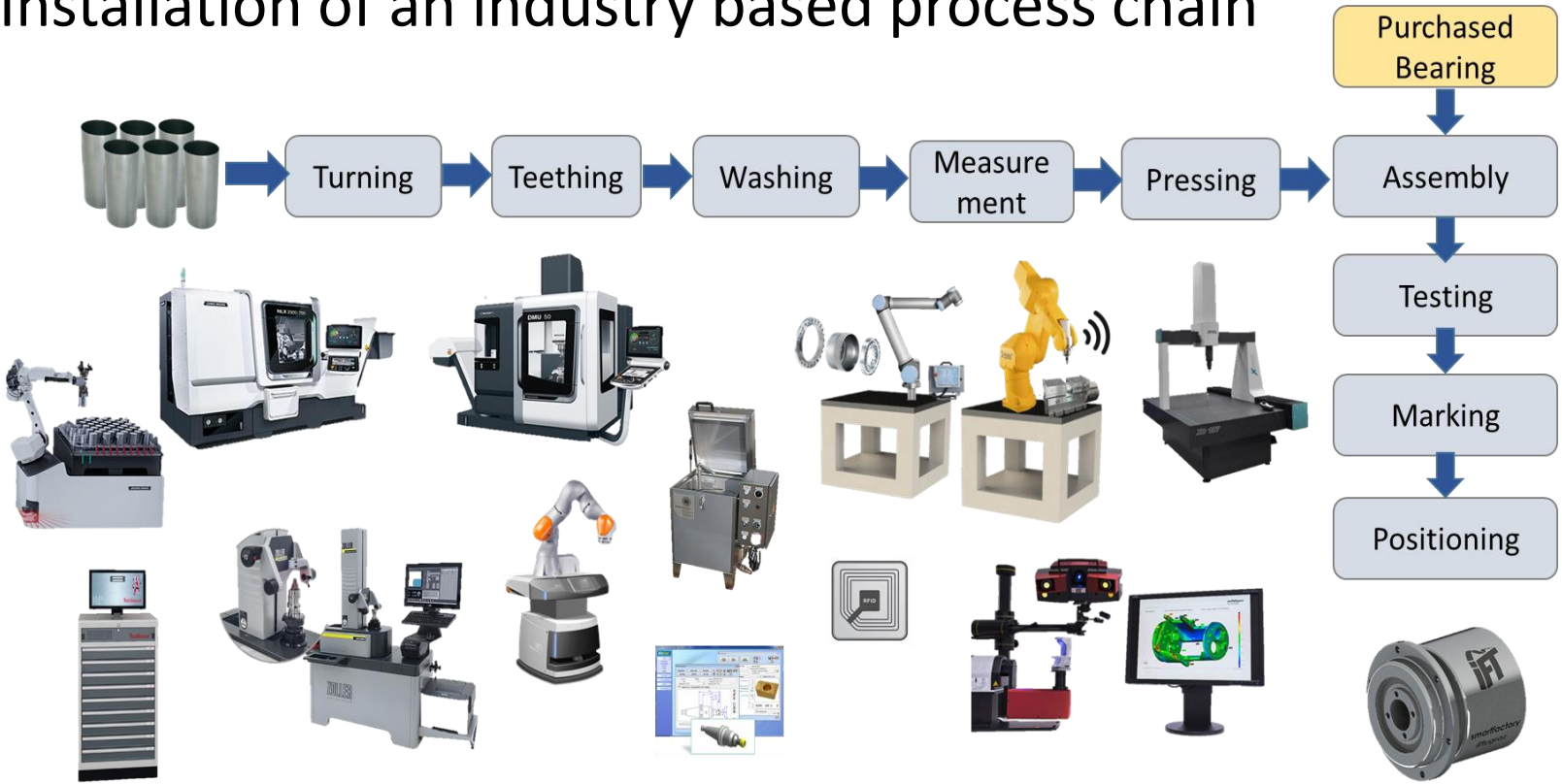
Institute of Production Engineering (IFT)

Industry 4.0 pilot factory: smartfactory@tugraz

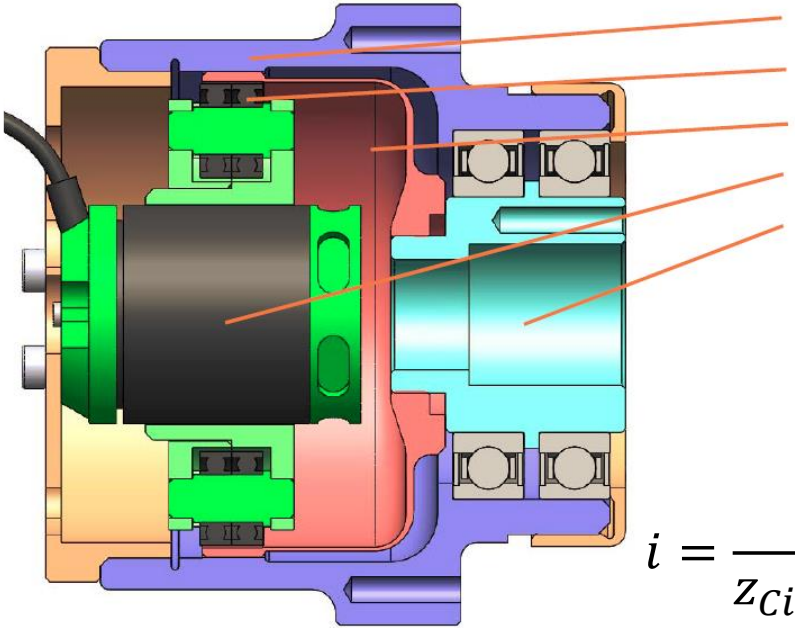
→ Agility

→ Data Security within a CPPS

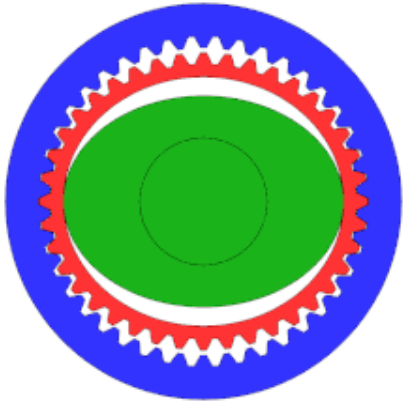
Installation of an industry based process chain



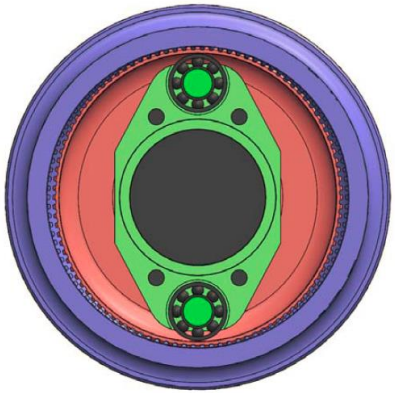
Case Study: robot smartgear



Circular Spline
Ball bearings
Flexspline
Motor
Gearbox-output

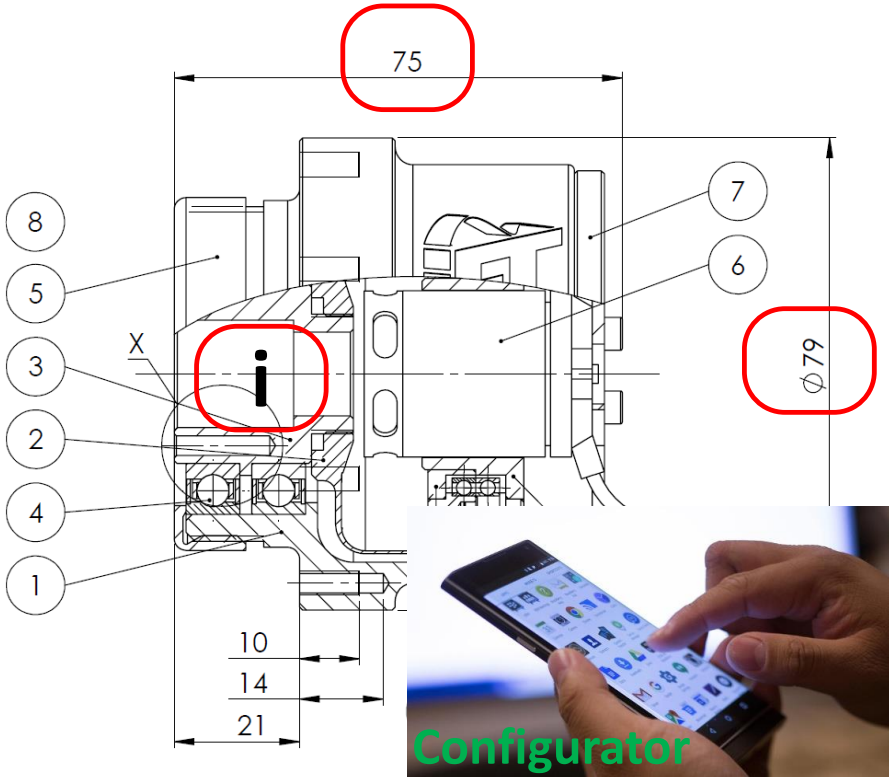


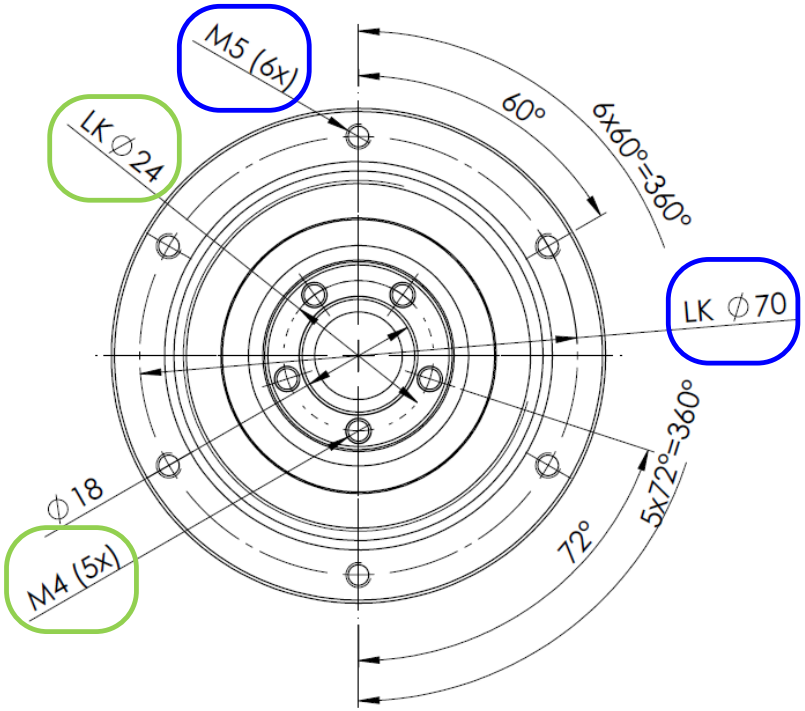
https://de.wikipedia.org/wiki/Harmonic_Drive#/media/File:HarmonicDriveAni.gif



$$i = \frac{z_{Circularspline}}{z_{Circularspline} - z_{Flexspline}}$$

Parametric Design





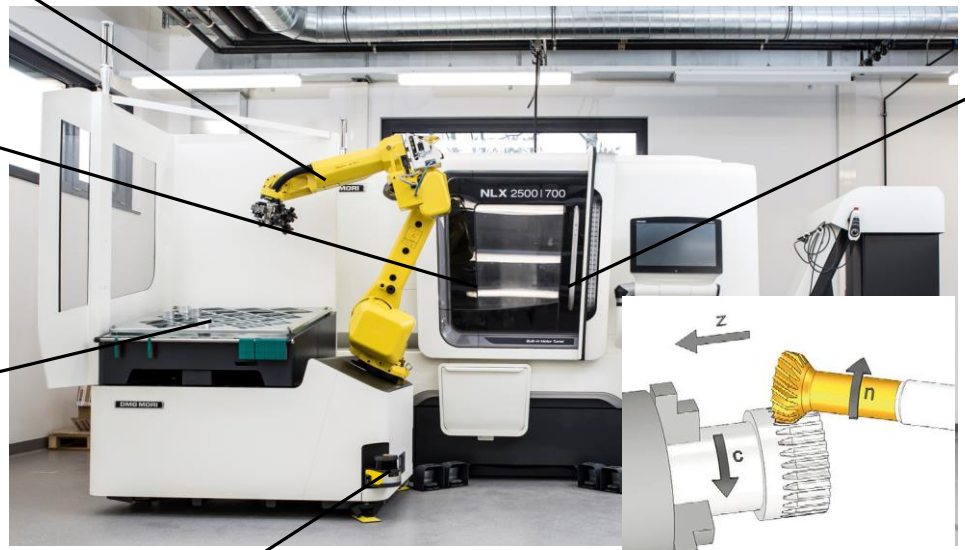
Machining Center (Core machine)

Industrial robot

1st Spindle

Raw parts

Safety camera

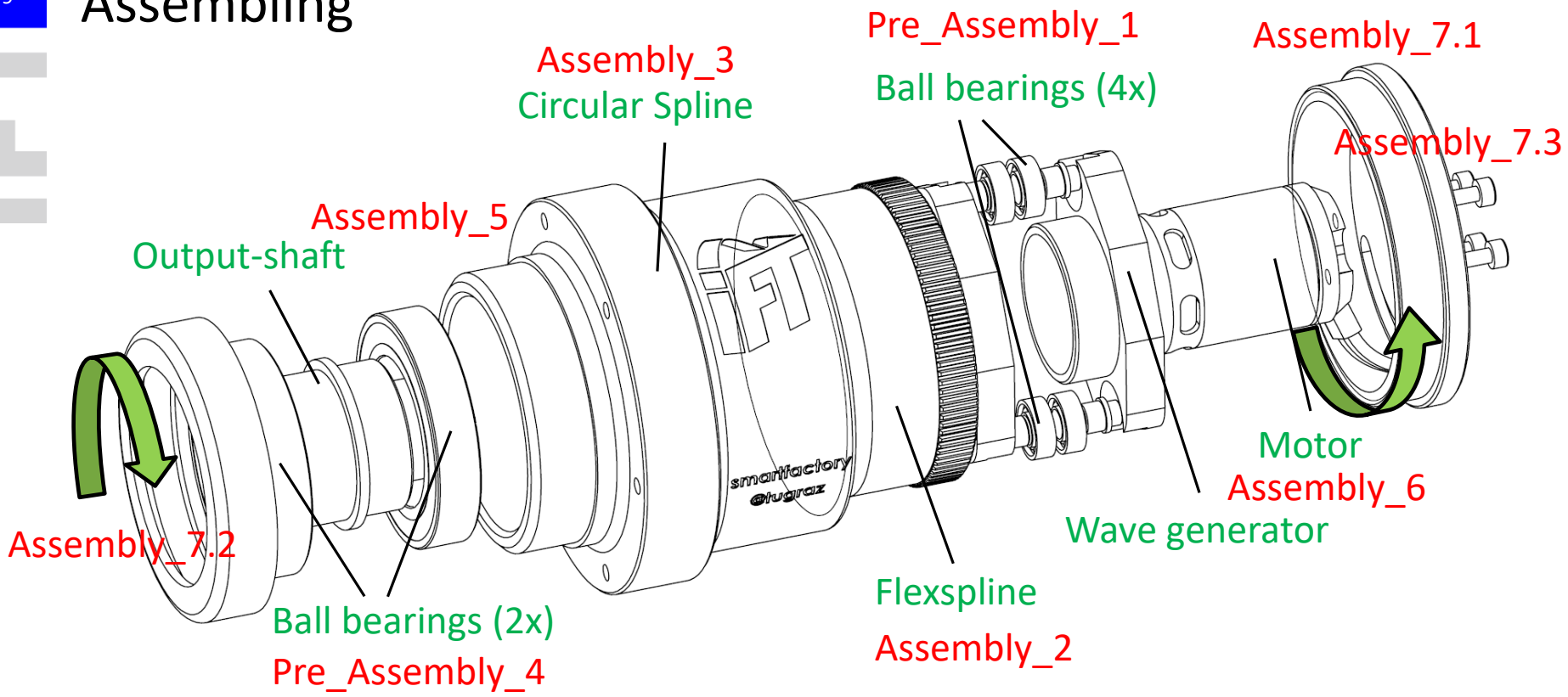


2nd Spindle

Gear skiving

https://www.wto-tools.com/en-us/products/turning-centers/gear-skiving/

Assembling


Pre_Assembly_1
Assembly_7.1
Assembly_3
Circular Spline
Ball bearings (4x)
Assembly_7.3
Assembly_5
Output-shaft
Motor
Assembly_6
Wave generator
Assembly_7.2
Flexspline
Assembly_2
Ball bearings (2x)
Pre_Assembly_4

TechCubes (TCs)

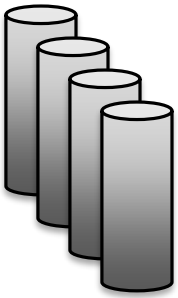
Tech Cubes - Autonomous machine beds

State of the art IIoT- quick and secure data exchange

Collaborative Robots – Examples for perfect Co-Working

Reconfiguration via air bearings

Workflow and factory concept with TechCubes (TC)



Raw Material

TC Pre_Ass 1

TC Pre_Ass 4

TC Ass_2-3

TC Ass_5-6

TC Ass_7

TC Test_1

TC Test_2

Final Products

Turning Center

Milling Center

NLX 2500/700

Workflow and factory concept with TechCubes (TC)

TC Pre_Ass 1

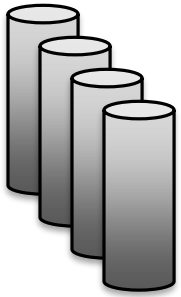
TC Ass_2-3

TC Pre_Ass 4

TC Ass_5-6

TC Ass_7

Raw Material



Final Products

TC Test_1

TC Test_2

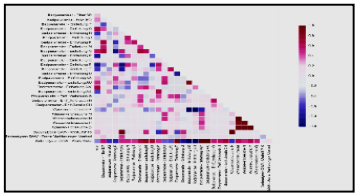
Turning Center

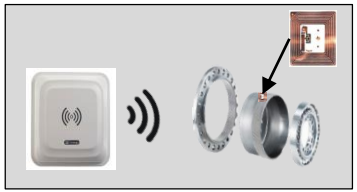
Milling Center

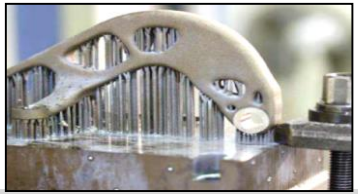
NLX 2500/700

Process/value chain needs intelligent systems

Research Areas in the smartfactory@tugraz



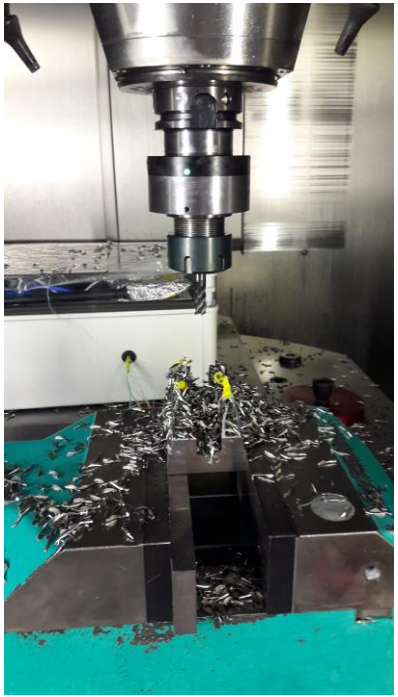


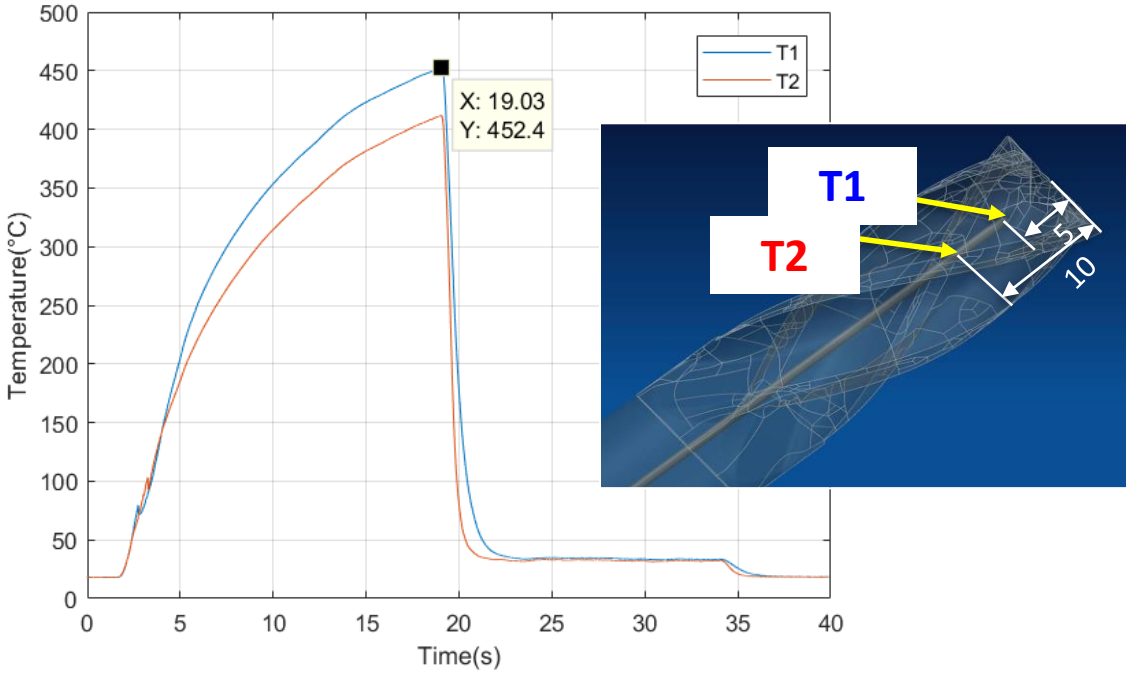


- Connectivity and digital integration
- Big Data 4 Manufacturing
- RFID-Applications in a harsh environment
- Increase of productivity in Additive Manufacturing

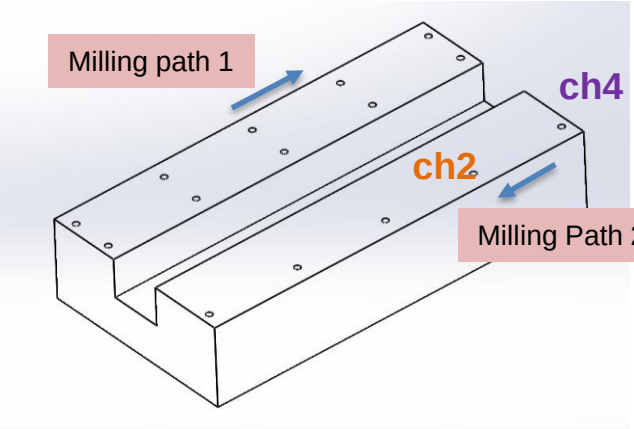
Sensor Networks for Artificial Intelligence

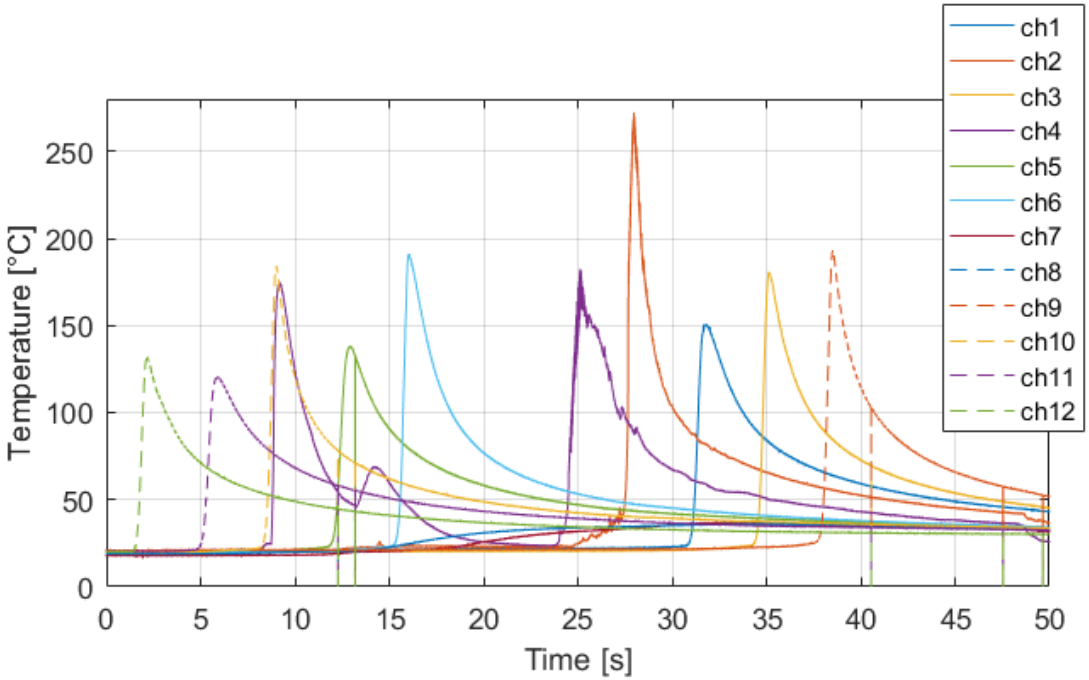
Milling temperature (SPIKE-System)



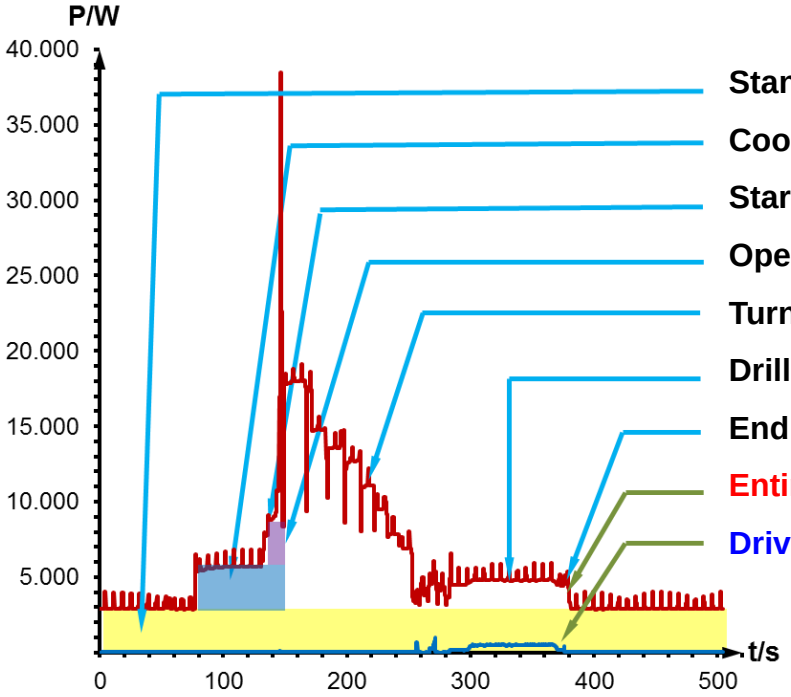


Machining Temperature as Key Performance Indicator





Power Analysis of Machine Tools



Standby-mode, basic load

Cooling system

Start of machining process

Operational-mode, ready to operate

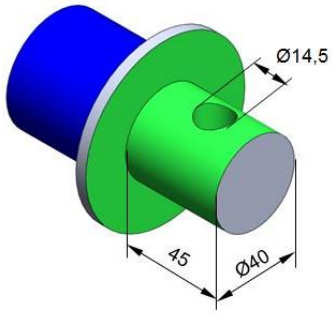
Turning

Drilling

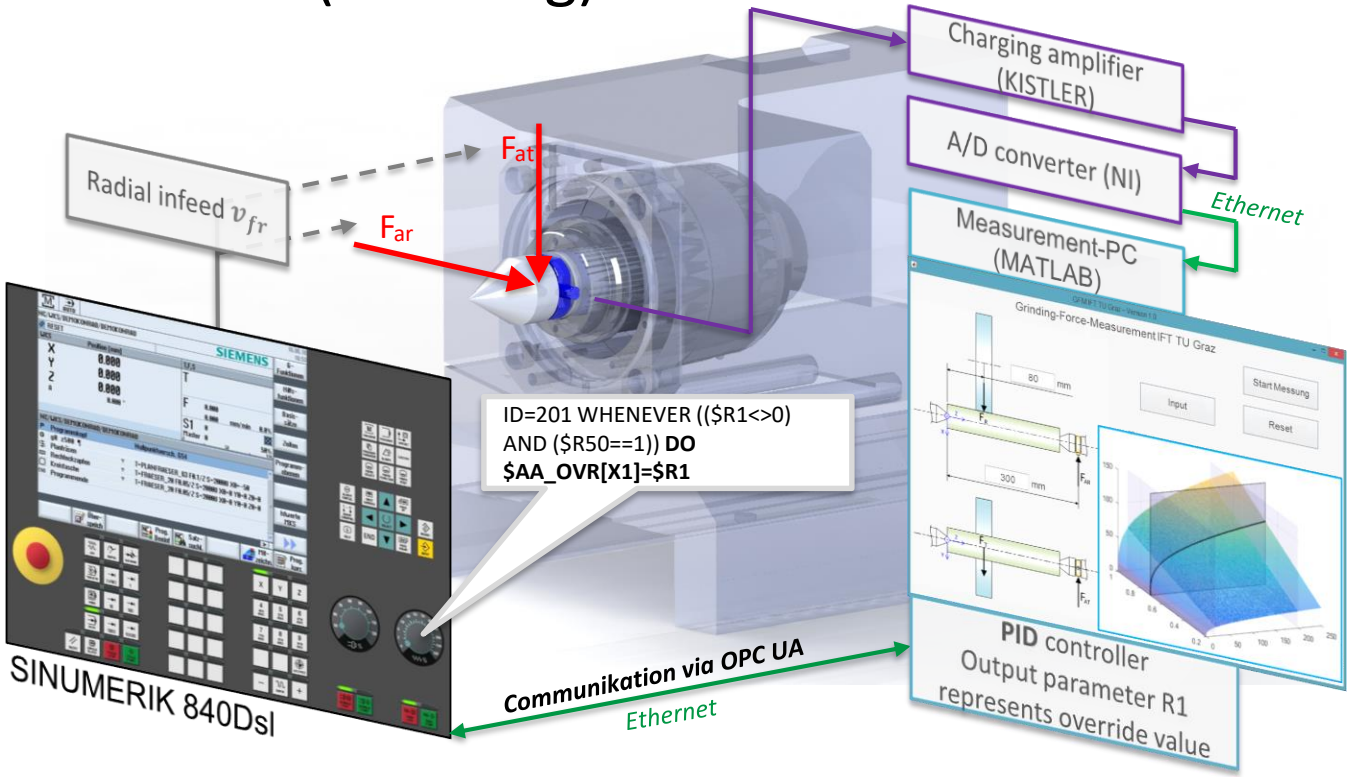
End of Operation

Entire power consumption

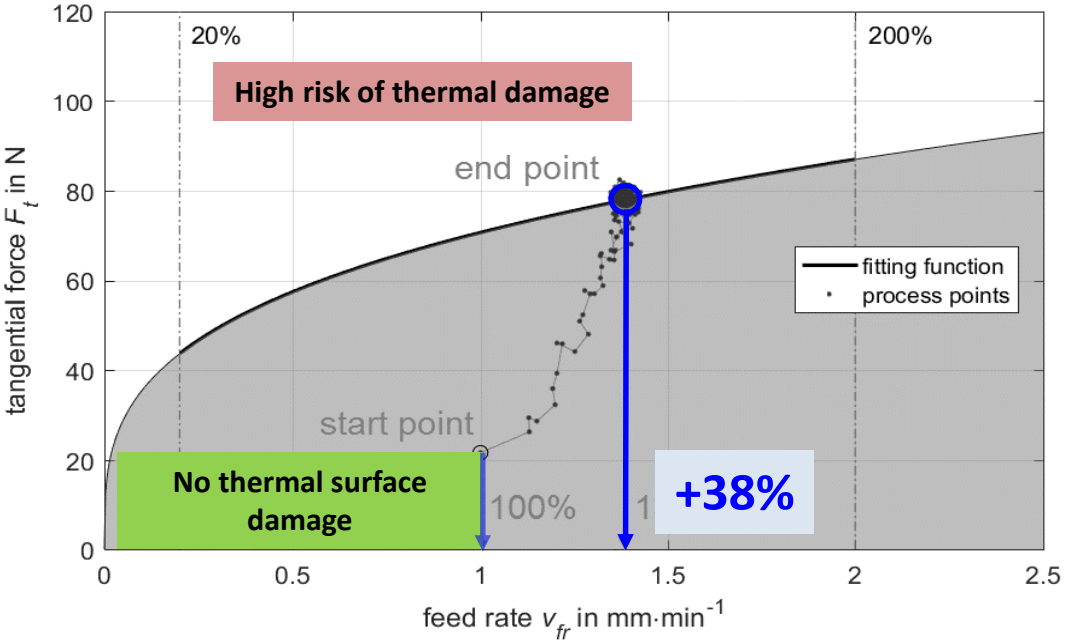
Drive system for driven tools



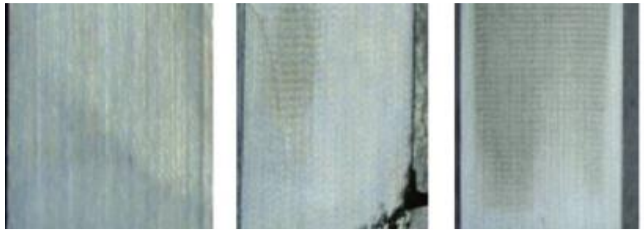
Adaptive Control (Grinding)



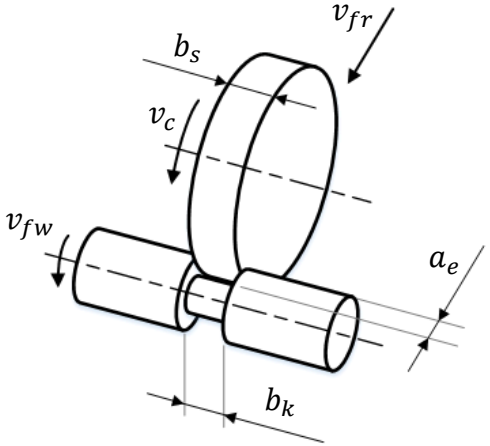
Improvements



Thermal surface damage



No Impact Low Medium



Conclusion

What we need?

- Modular Construction
- Parametric Description
- Modern Machinery
- TechCubes for assembling
- Sensor networks
- Not to many restrictions at the beginning.
- Spirit and motivation