

MODUL 5: CAD/CAM-Tools and Edge Computing

DIH-Süd | Digitalisierung in der Zerspanung

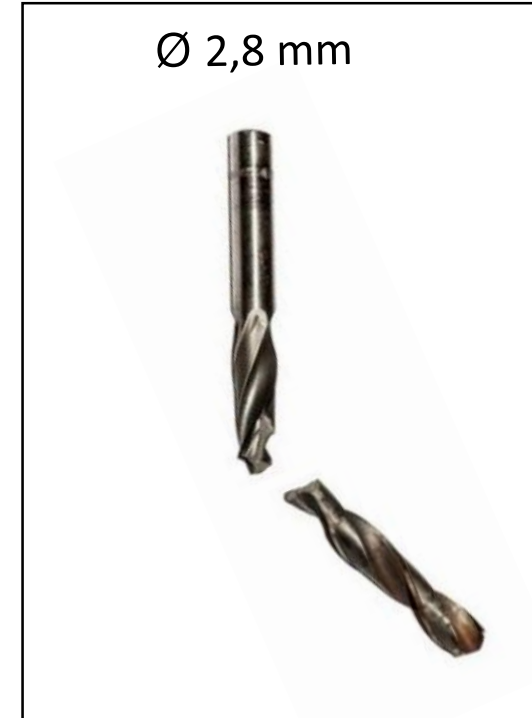


Overview

- ☐ Edge Computing: Motivation & Possibilities
- ☐ Preparation: Data Acquisition & Experiment Set-Up
- ☐ Network Architecture
- ☐ Conduction of Experiments
- ☐ Development of Machine Learning Models
- ☐ Edge App: Implementation & Application
- ☐ Learning Factory Showcase „Edge Computing“
- ☐ Summary & Outlook

Motivation for Edge Computing

- ☐ Problem: Drill Breakage
- ☐ Requirement: no Drill Breakage
- ☐ Activity: System for Prediction of Drill Breakage



Source: https://de.123rf.com/photo_28493217_abgebrochenen-bohrer-f%C3%BCr-metall-isoliert-auf-wei%C3%9Fem-hintergrund.html

Motivation for Edge Computing

- ❑ Problem: Drilling Process



Source: <https://www.taegutec.com>

Motivation for Edge Computing

- ❑ Drilling Process: Manual Tool Change



Source: <https://www.glacern.com/>

Motivation for Edge Computing

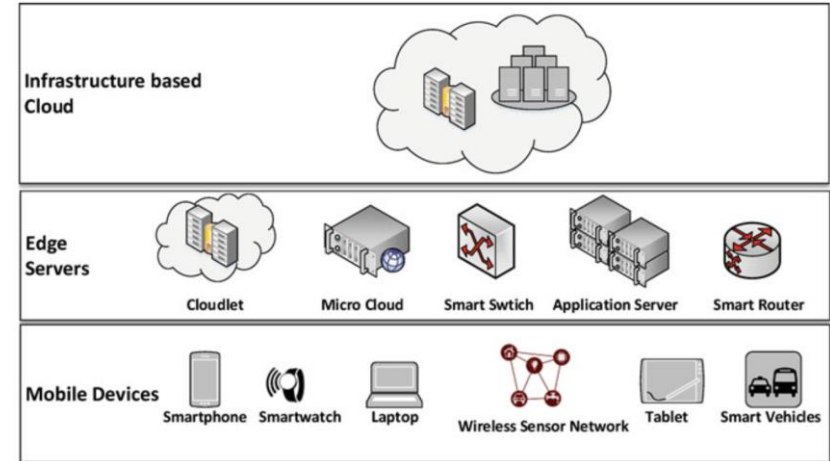
- ❑ Drilling Process: Automatically Tool Change



Source: <https://www.glacern.com/>

Possibilities of Edge Computing

- ☐ Distributed Cloud Computing Paradigm
- ☐ Reduced Data is sent to the Cloud
- ☐ Data Processing at Proximity to the Data Source
- ☐ Local Analysis for Faster Response
- ☐ Unloading of the NCU of the machine tool



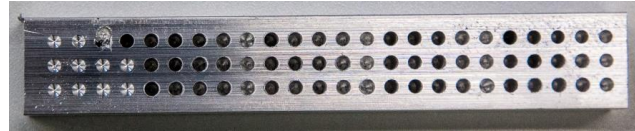
Source: Edge Computing – From Hype to Reality, Fadi Al-Turjman, Springer, 9 Nov 2018

Preparation Data Acquisition

- ☐ Point of Interest: Actual value Characteristic for Drill Breakages
- ☐ Drill Process: Realistic Wear of the Drill Bit and intentional Breakage
- ☐ Capturing of Axis Drive Data
 - Low Frequency Data (LFD) via OPC UA (time interval: 100 ms)
 - High Frequency Data via SINUMERIK Edge (time interval: 2 ms)

Experiment Preparation

☐ Workpiece



- Material: AlCuMgPb
- Dimensions: 20 mm x 15 mm x 125 mm

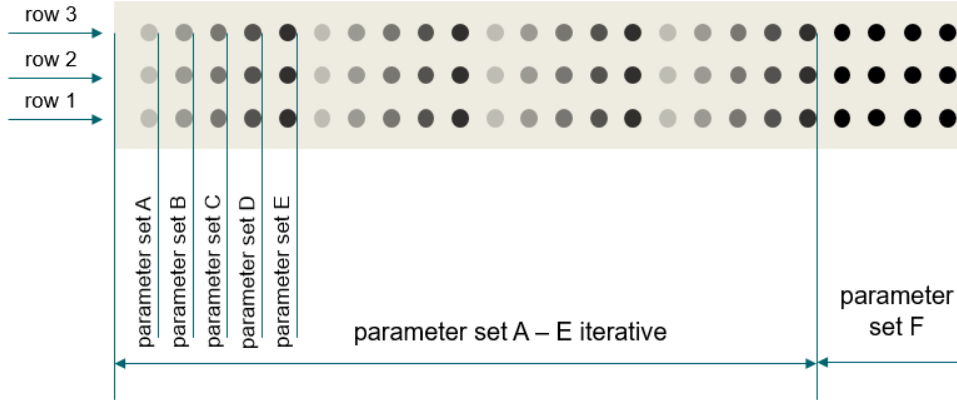
☐ Tool

- Name: Spiral Drill
- Material: HSS Titanium
- Coating: Nitride
- Dimensions: 2.8 mm x 61 mm



Experiment Preparation

□ Workpiece Parameter Sets



Experiment Preparation

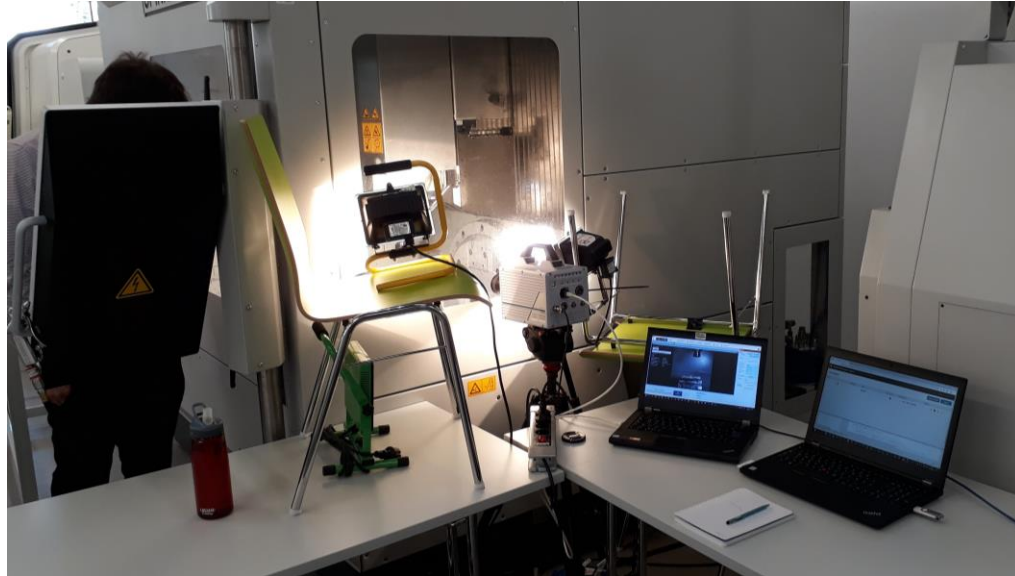
☐ Machine Tool Parameter Sets

Parameter Set	Tabular Value	Rotational Speed	Drilling Depth
A	Lower Values	5456 min ⁻¹	5,46 mm
B	Upper Values	7389 min ⁻¹	7,39 mm
C	Upper Values + 20%	8867 min ⁻¹	8,87 mm
D	Upper Values + 30%	9606 min ⁻¹	9,61 mm
E	Upper Values + 40%	10345 min ⁻¹	10,35 mm
F	Upper Values + 80%	13300 min ⁻¹	13,30 mm

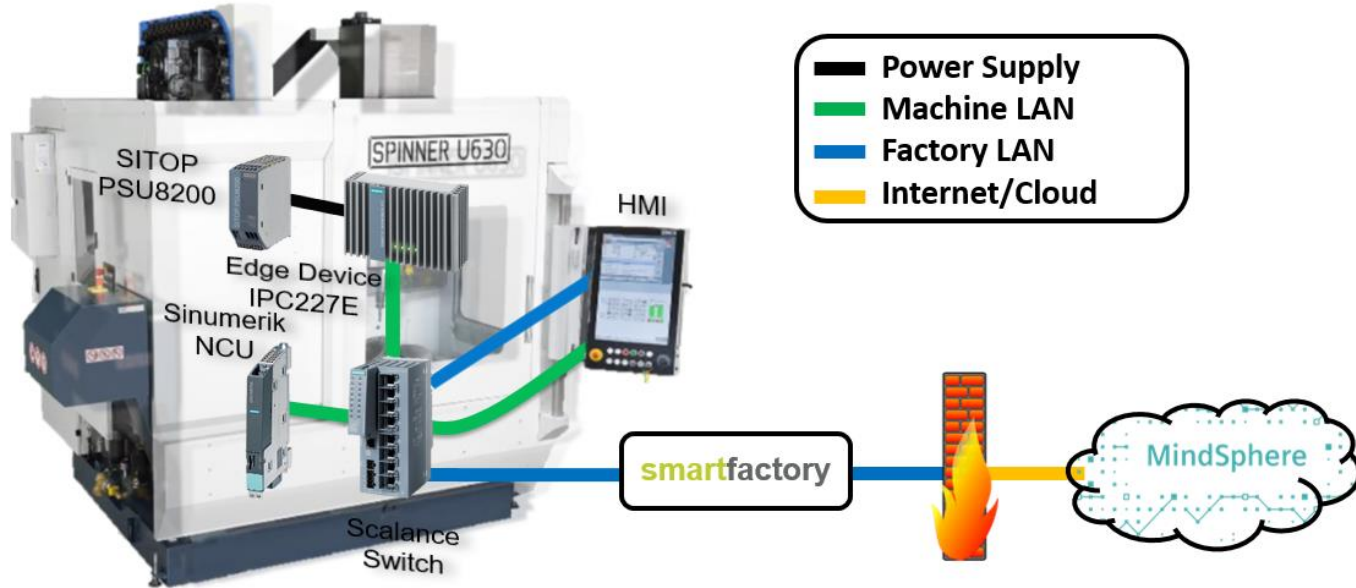
Every Parameter set with a constant Feed Rate of 0.12 mm / rev

Experiment Preparation

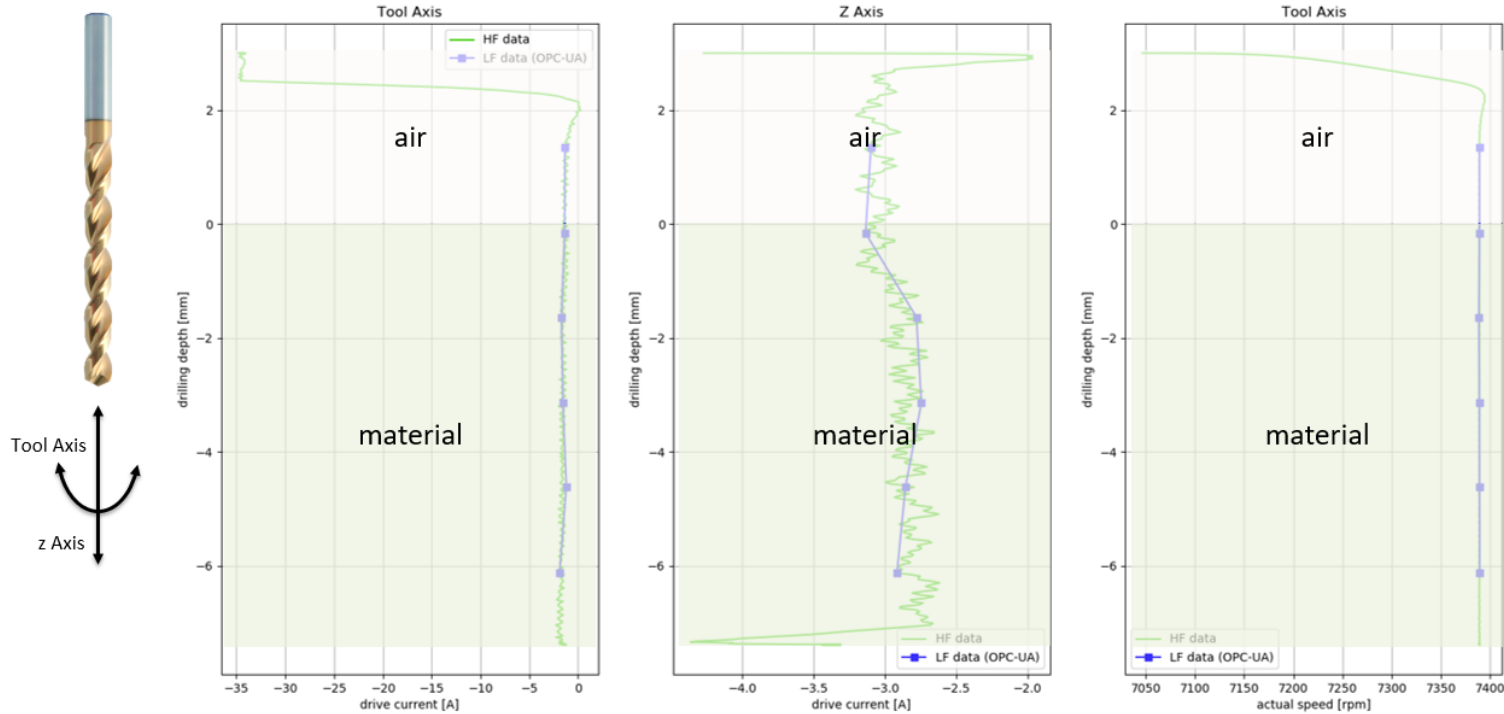
- ☐ Preparation für Recording with High Speed Camera



Network Architecture



Conduction of Experiments

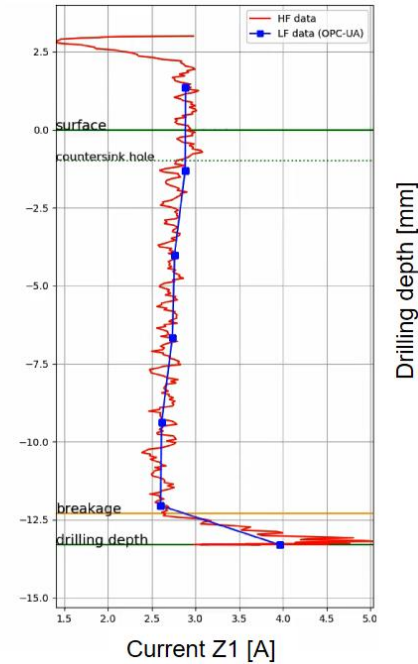
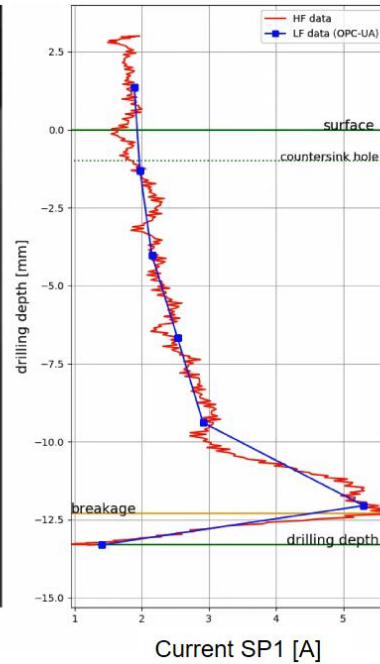


Conduction of Experiments

Measuring Data



$n = 13300 \text{ min}^{-1}$
 $f = 0,12 \text{ mm}$



Conduction of Experiments

- After the Drilling Procedure



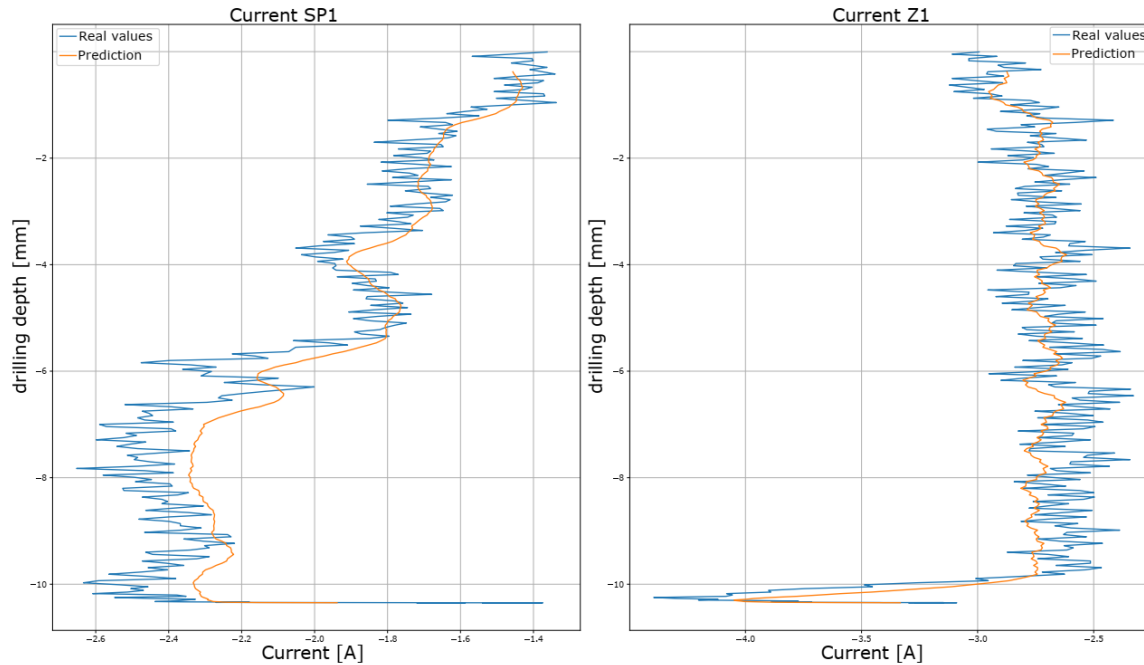
Development of Machine Learning Models

☐ LSTM (Long Short Term Memory)

- Predicts Drive Current
- Learning through Training Data
- Future Values are predicted on the Basis of past Values

Development of Machine Learning Models

□ LSTM: Results

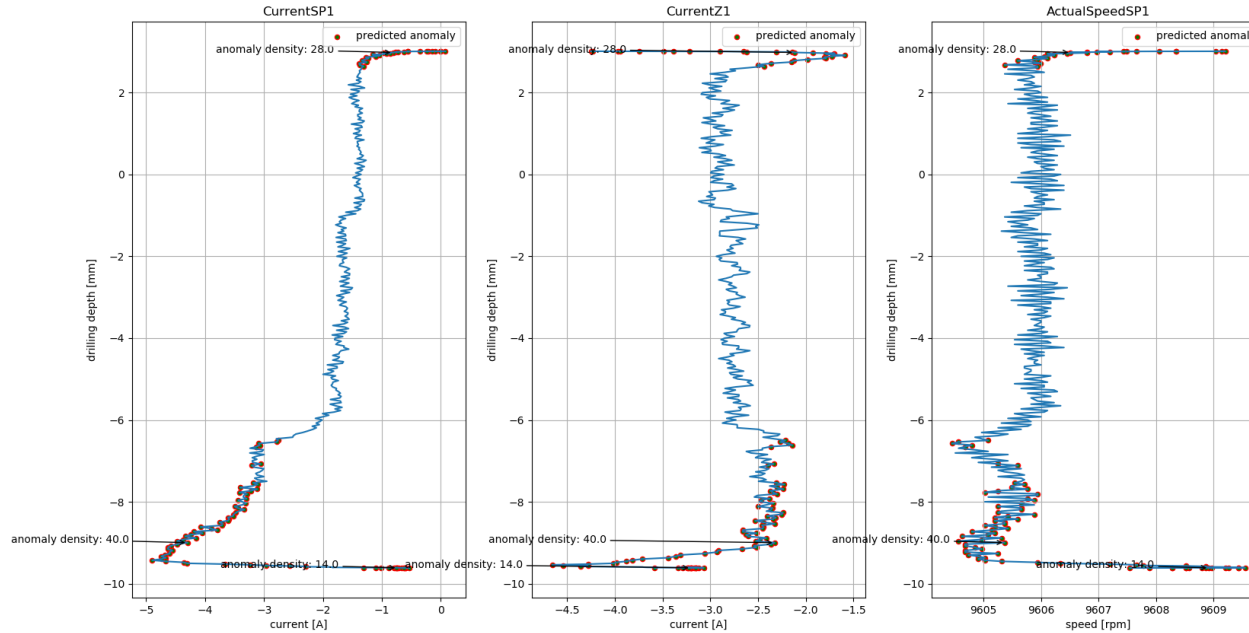


Development of Machine Learning Models

- ☐ Isolation Forest
 - Classifies Measuring Data
 - Learning through Training Data
 - Setting of expected Anomalies by Parameter “Contamination”

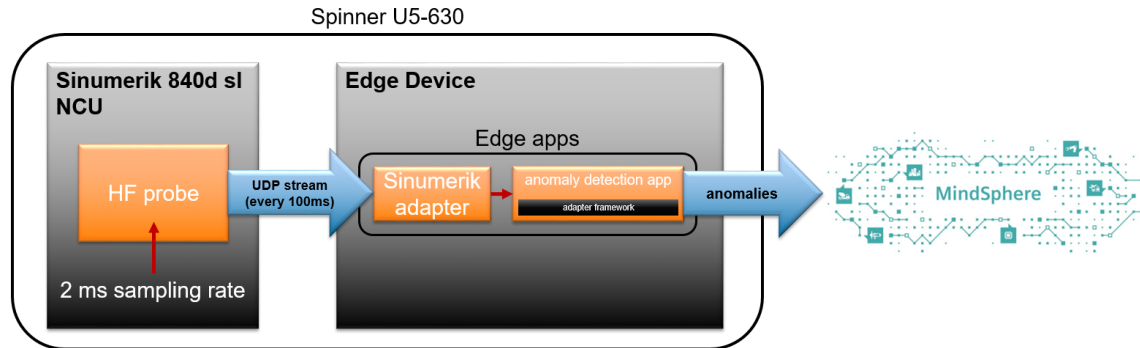
Development of Machine Learning Models

Isolation Forest



Development and Implementation of an Edge App

- ❑ „DaDetection“: Edge App for Anomaly Detection
 - Identifies Anomalies in real Values via Isolation Forest
 - Data of Interest is sent to the Cloud



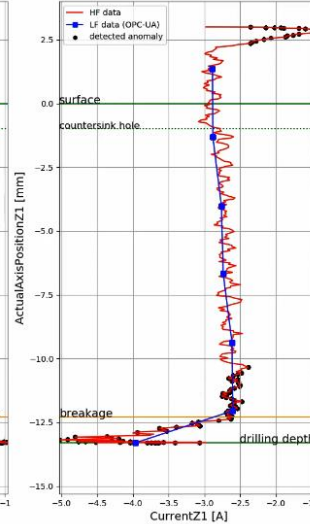
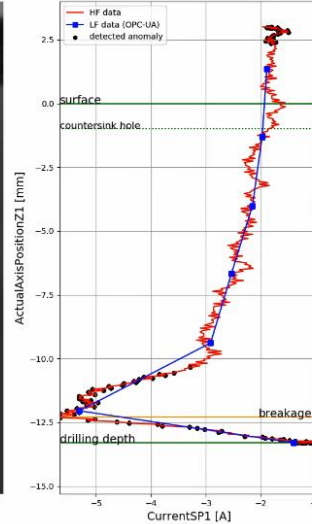
Application of Isolation Forest with Edge App

- Measuring data with detected Anomalies

data from z and tool axis drive

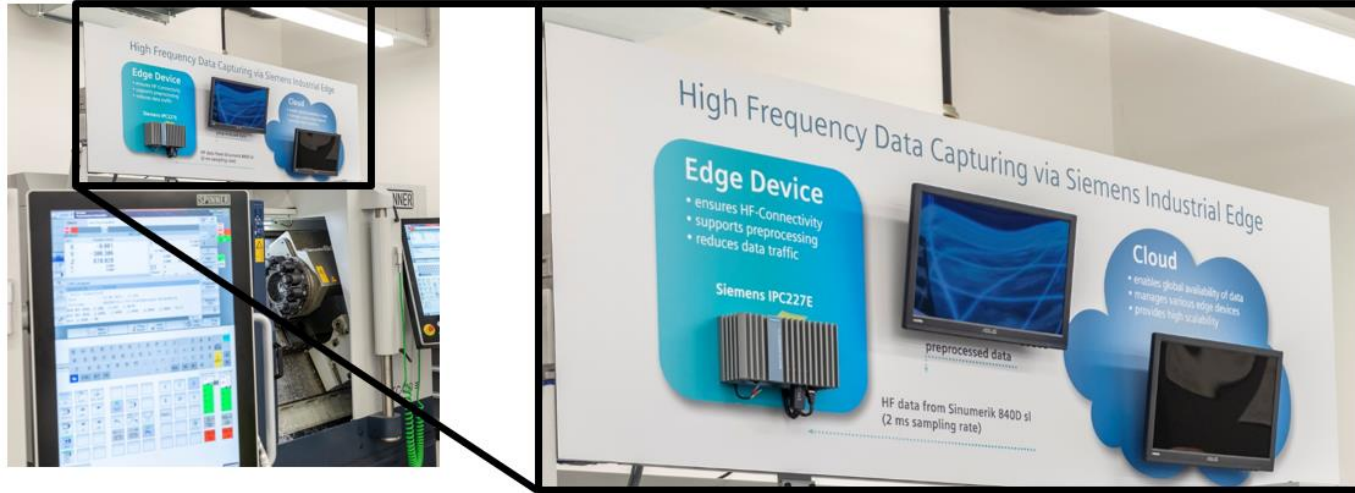


$n = 13300 \text{ min}^{-1}$
 $f = 0,12 \text{ mm}$



Learning Factory Showcase „Edge Computing“

❑ Edge Computing Board



Summary

- Prediction of Drill Breakage: works
- Tool Usage can be increased and Tool Costs can be cut down
- Strong Method for getting more Knowledge about the actual Condition of a drilling Tool while being in Action
- Huge Amount of Data is generated without additional Hardware-Sensor Installations
- Reliable and Secure Exchange of Data into the Cloud
- Profound Knowledge in: Network Engineering, Data Analytics and Machine Learning

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