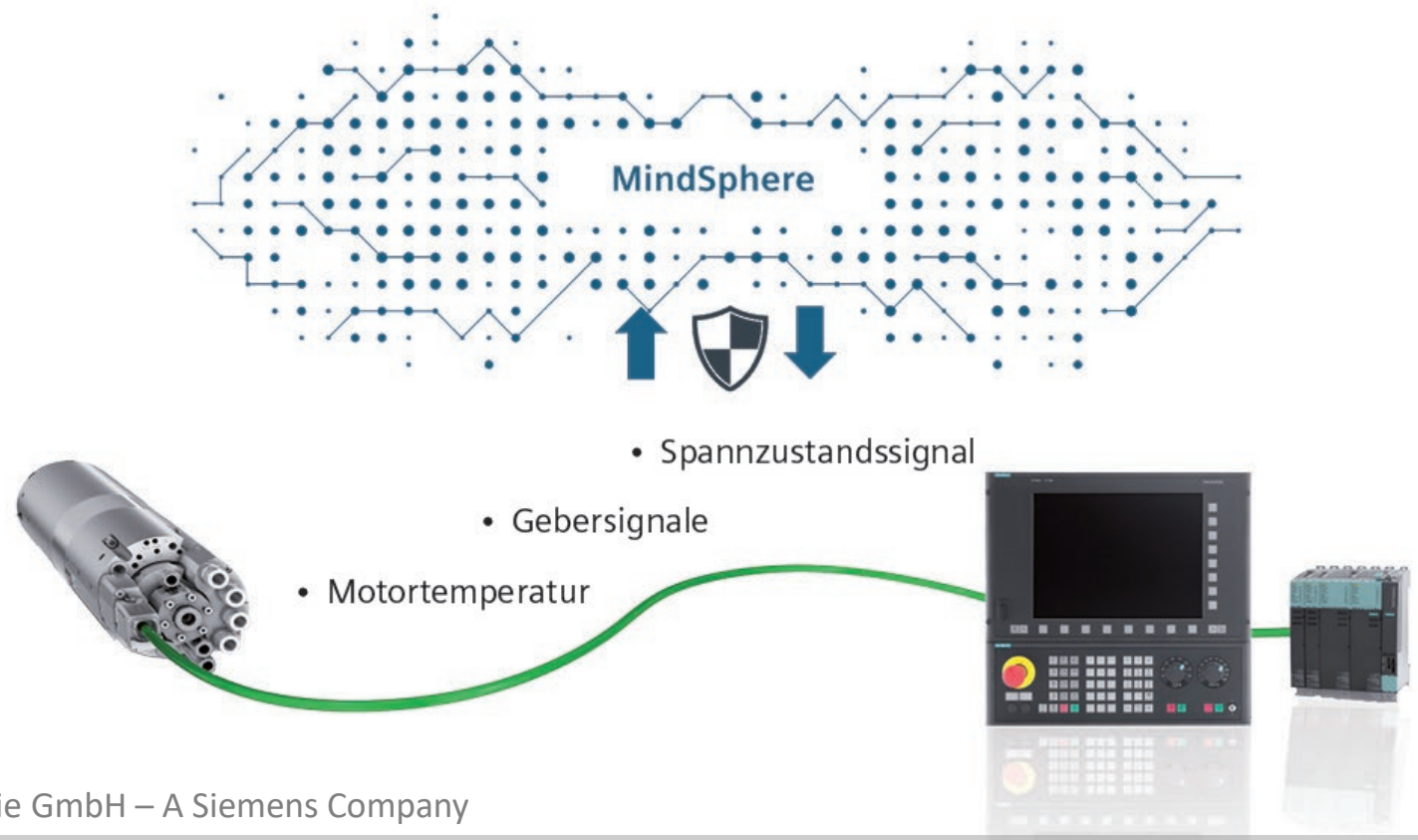
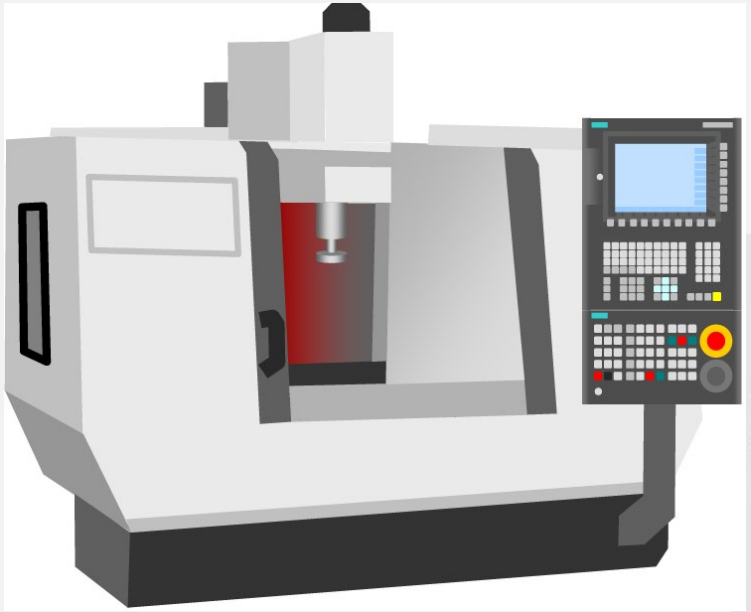
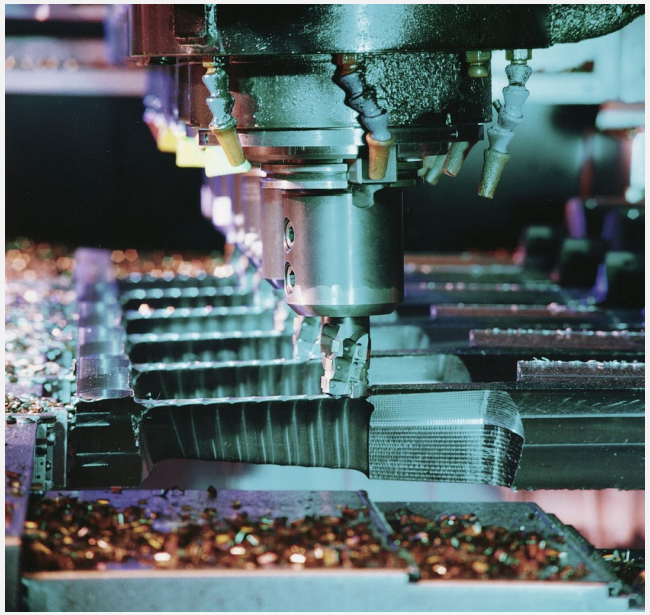


WEISS Spindeltechnologie GmbH – A Siemens Company

DIGITIZED SPINDLE

MACHINE TOOL SPINDLE





Machine tool spindles influence **the productivity**

…….the product quality

……. the holding time

of a machine tool**.**

DIGITIZED SPINDLE
LEAD FOR MORE PRODUCTIVITY

Simply installation and robust operation

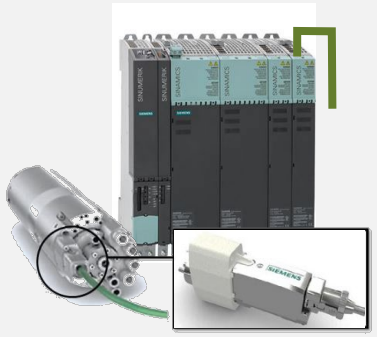
- Digital signal transfer
- Robust opposite EMV disturbances
- Transferring the motor drive parameters automated
- Integrated processing of analogous tool clamping status

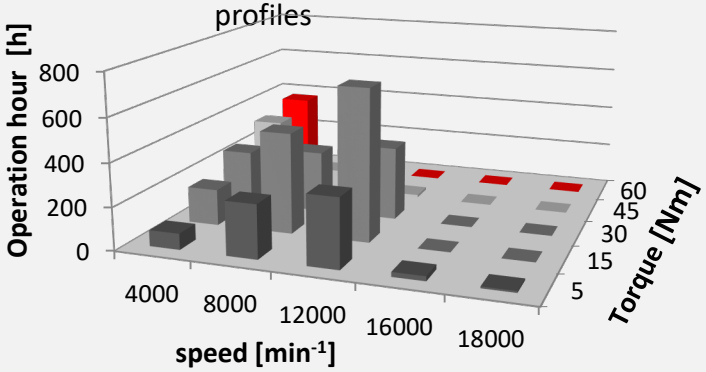
Data record for preventive maintenance

- Condition Monitoring
- Data record on internal data server
- Analysis of the data
- Detection of trends and Overshoots of temperature limits
- Reference to critical operating states
- Speed and torque profiles

Stateful maintenance

- Operating hours counter
- Counter of clamping cycles
- Digital identification
- Recording of temperature
- Analysis of clamping times of the tool clamp system
- Supervision of the tool clamping process





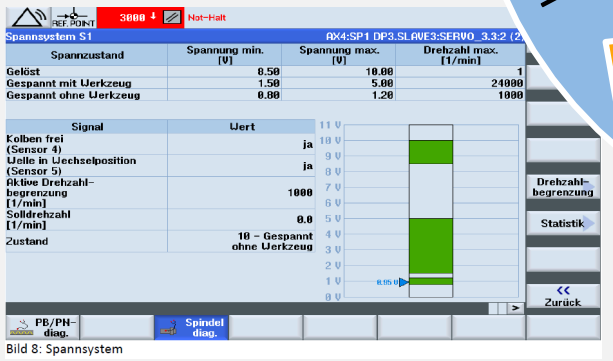
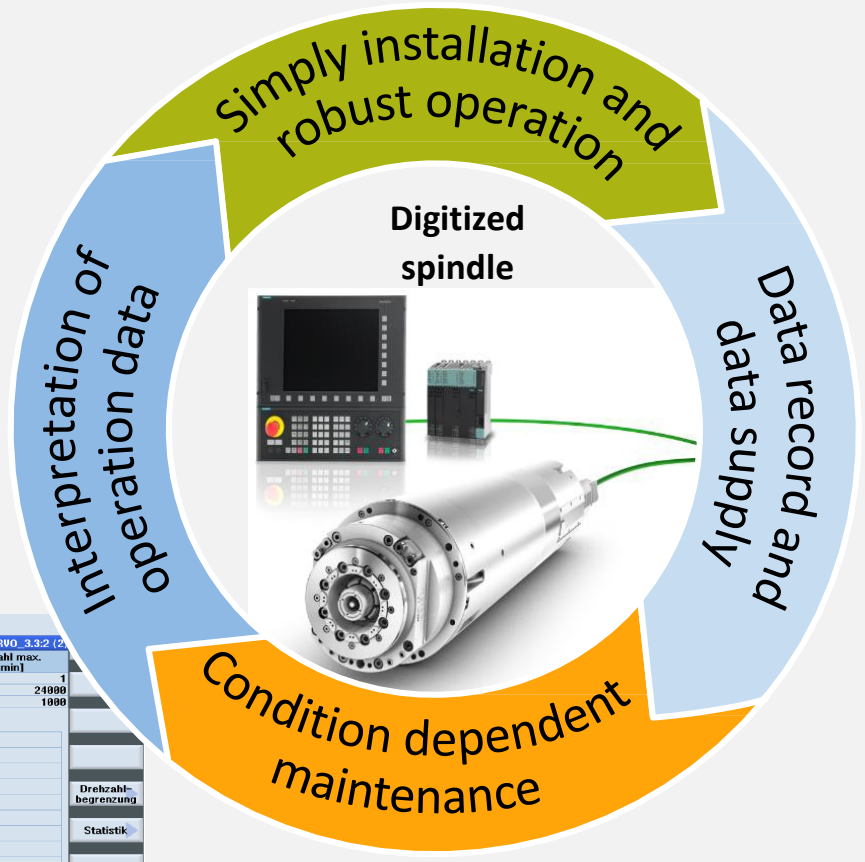
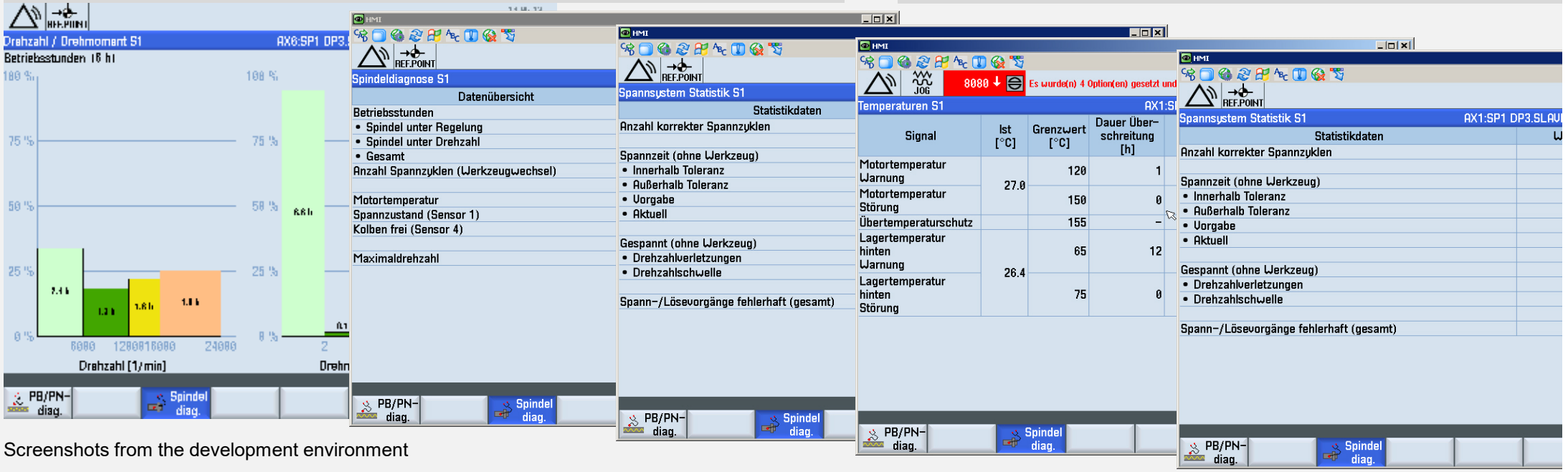


Bild 8: Spannsystem

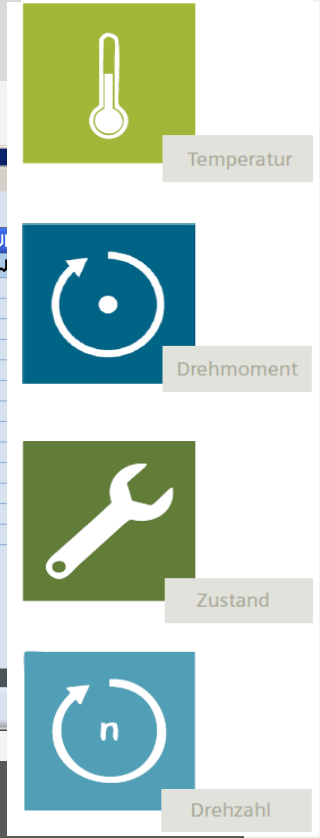


DIGITIZED SPINDLE
INTEGRATED SPINDLE MONITOR ISM

Feature	Benefit
Integrated Spindle Monitor ISM	**Additional information about spindle data gives a feedback refer to spindle condition.**

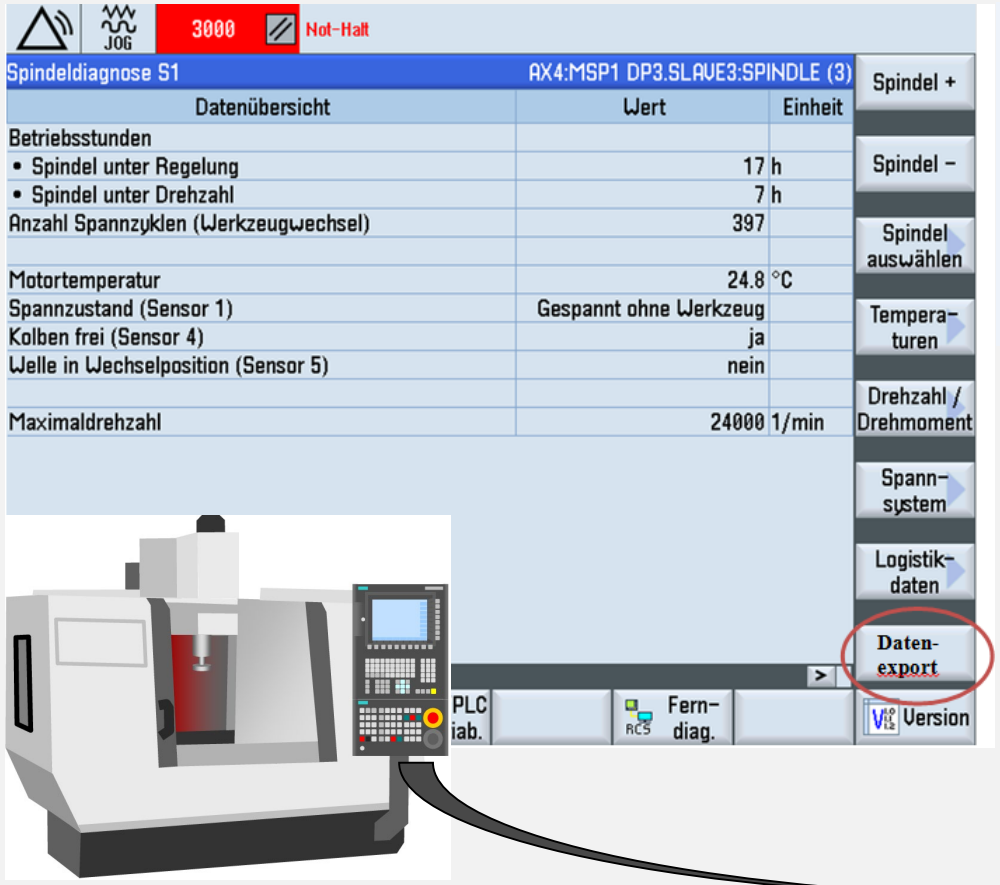


Screenshots from the development environment



Option integrated spindle monitor ISM for more spindle diagnostic.

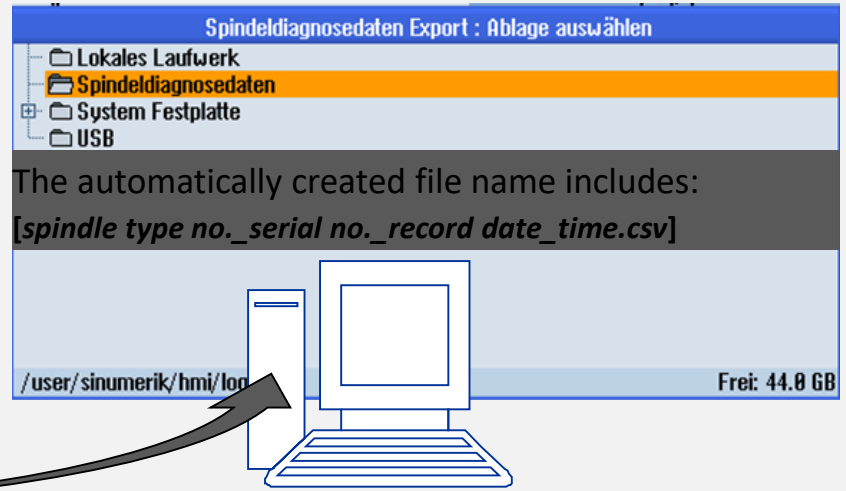
DIGITIZED SPINDLE
INTELLIGENT NETWORKING OF THE SPINDLE IN PRODUCTION



Setup for data export

Spindeldiagnosedaten Export

Einstellungen	Wert
Ablage	/user/sinumerik/hmi/log/spindiag
Intervall	Täglich
Uhrzeit	Täglich
	Wöchentlich
	Monatlich

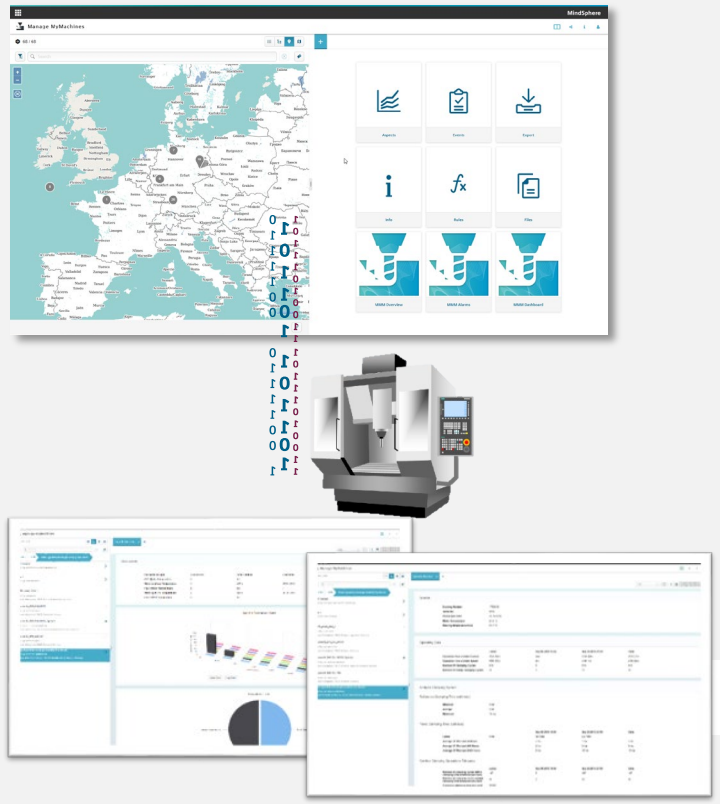


Company network

[1)]Only for SINUMERIK 840D sl SW4.5 SPx

With optional data export[1)] SMI24 data can be recorded as a csv file.

DIGITIZED SPINDLE CONNECTION WITH AN OPEN IT OPERATING SYSTEM



Feature / Function

- Dashboard displays the information on the master data of the connected main spindle
- Statistics for operating points: speed / torque / temperature
- Statistics on tool clamping times
- Statistics on the clamping condition
- Selection and comparison of statistical data at different points in time
- Export of saved data in a standard CSV format

Benefit

- Time-efficient access to required information in case of maintenance or service
- Information on possible power reserves and suitability of the design
- Evaluation of the clamping times in comparison to the reference value
- Detection of wear of the clamping system through change of the clamping times
- Recognition of changes in use
- Management and monitoring of globally distributed machine parks
- New service methods and business models

Further Information: https://documentation.mindsphere.io/resources/html/manage-my-machine/de-DE/index.html

SPINDLE WEAR PARTS AND POSSIBLE SPINDLE FAULTS

Analysis

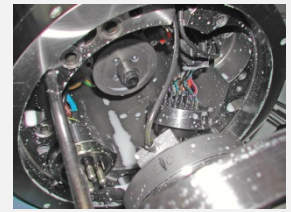
- Operation times in reference to Speed and torque ranges
- Clamping times
- Number clamping cycles
- Trend analysis of motor and bearing temperature
- Temperature overshoots

can point out an existing process of an spindle failure or can give important information during a diagnostic of the causes of failure after a spindle fault.

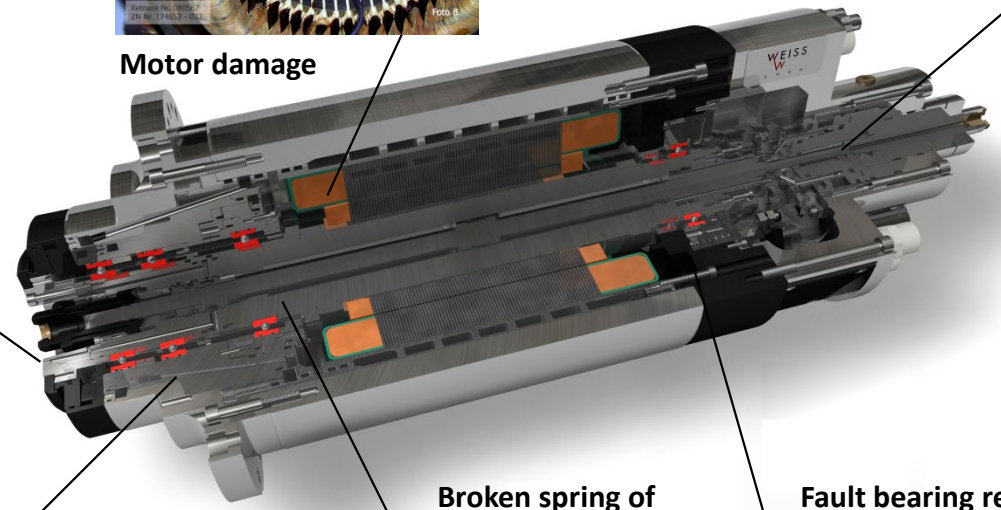
Condensation

Motor damage

Cooling damage



Fault rotary union and consequential damages



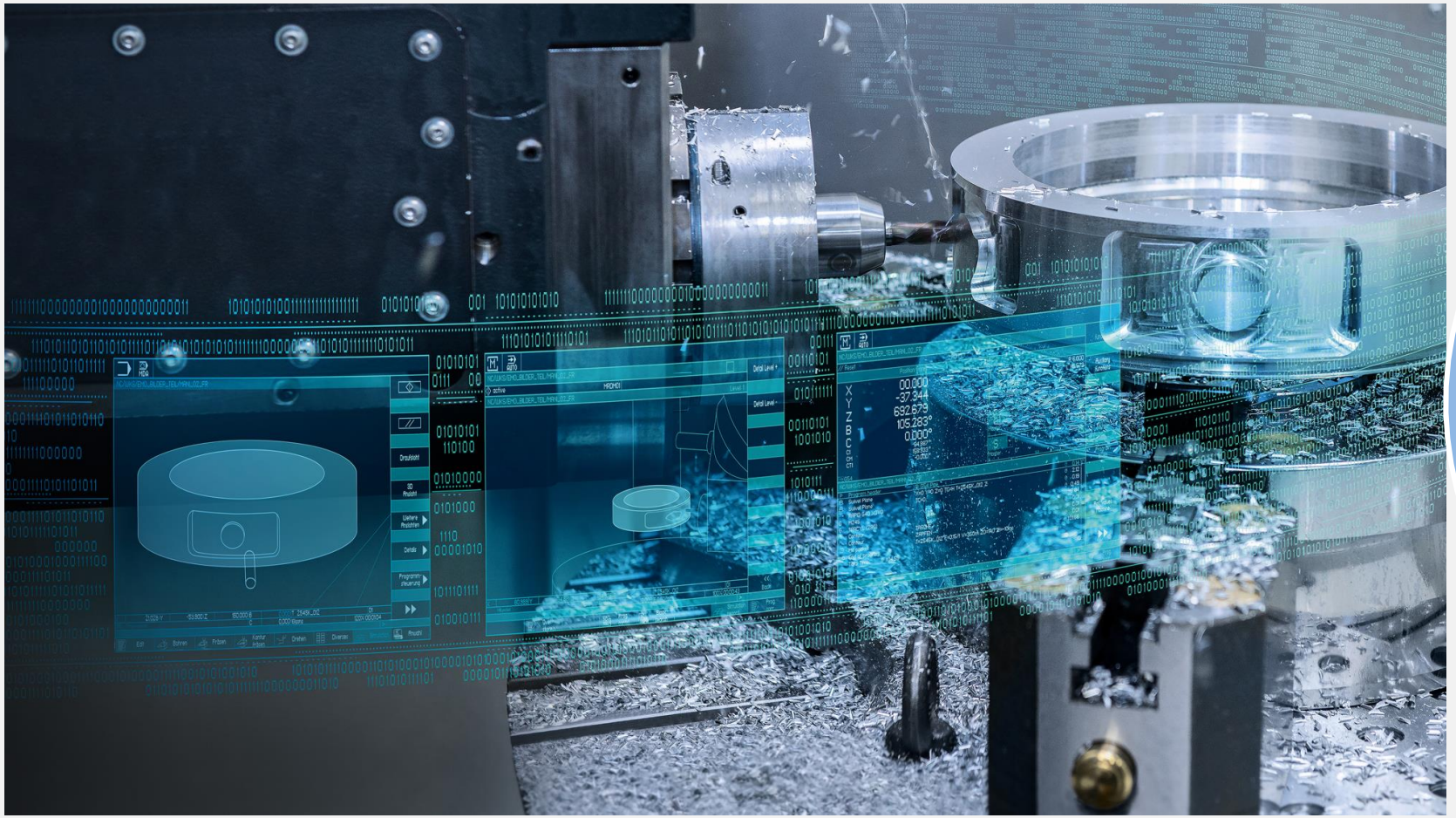
Damaged tool interface

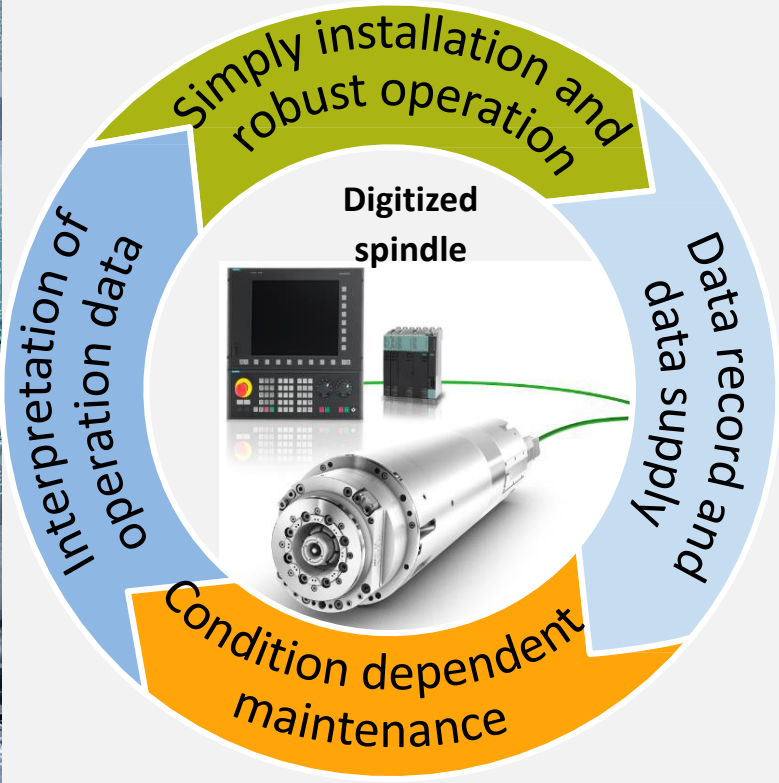
Fault bearing front site

Broken spring of clamping unit

Fault bearing rear site

INTERPRETATION OF OPERATION DATA





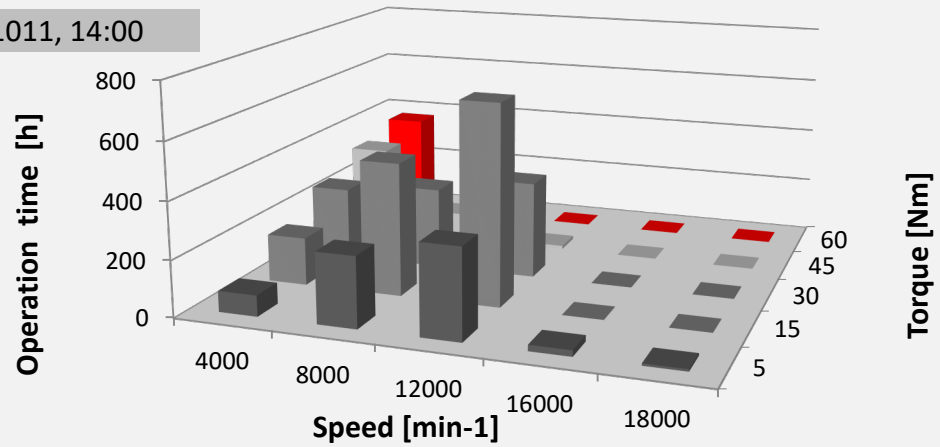
The following slides shows exemplary possible interpretations of operation data

EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

Spindle Typ: 175442L	Time data export: 20161011, 14:00
Serial No.: 168	
Production date: 27.03.2013	

Operation hours

Operation hour under control:	5020 h 36 min
Operation hour under speed:	5010 h 22 min
Number clamping cycles:	902520
Number fault clamping cycles:	65

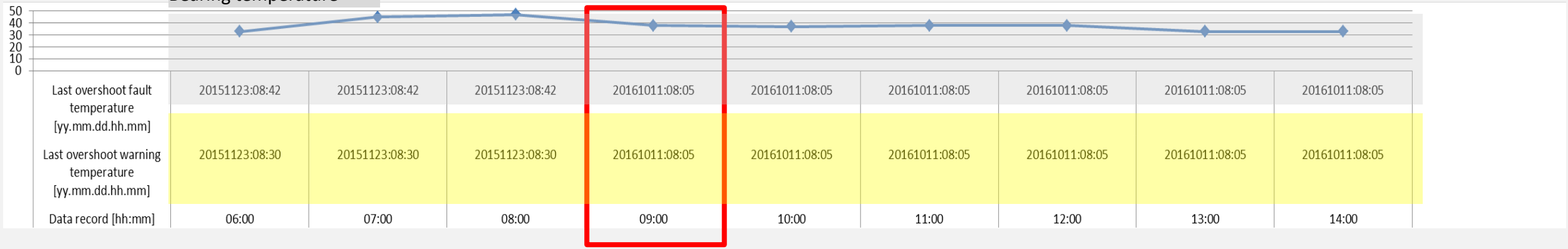


Trend analysis clamping time

Reference clamping time	
Minimum:	46,808 ms
Average:	50,594 ms
Maximum:	71,875 ms
Last 24 hours:	52.112 ms
Last 10 days:	50.715 ms
Last 100 days:	50.502 ms

ºC

Bearing temperature

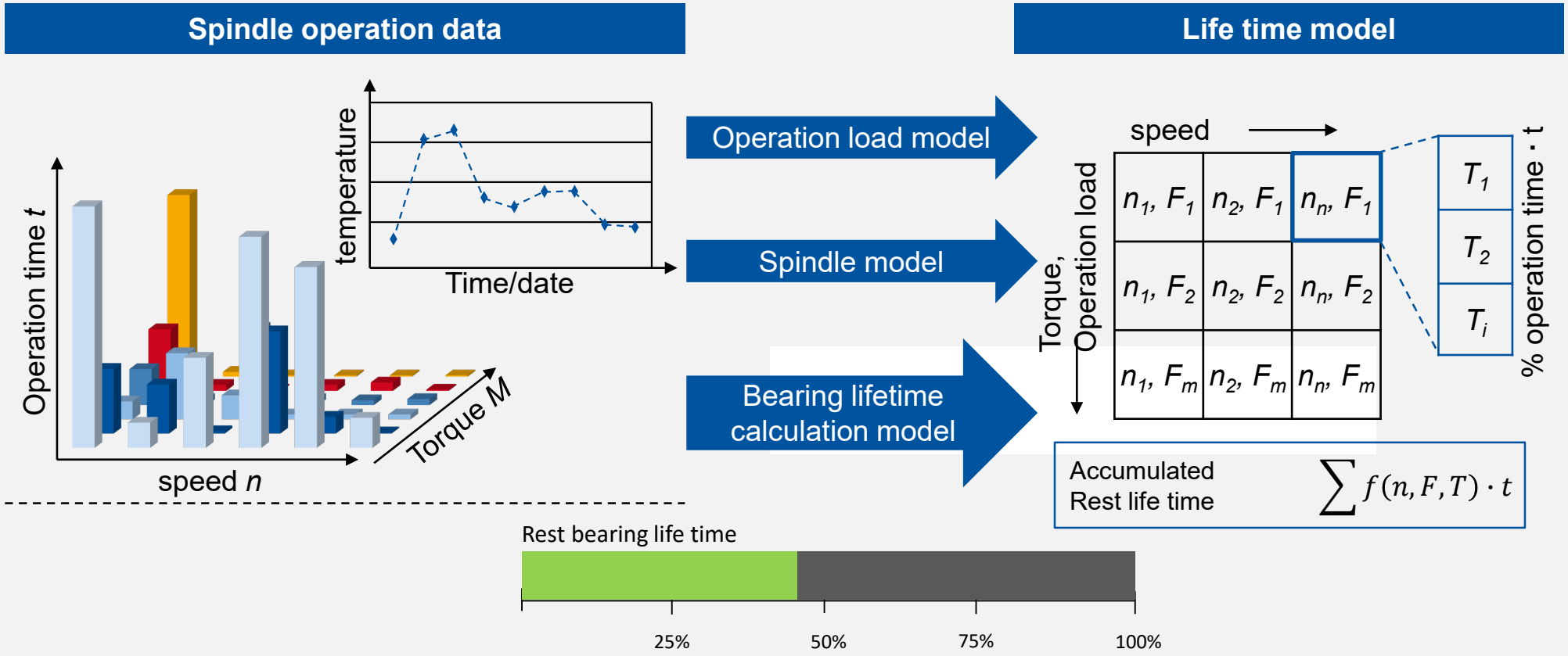


Last overshoot fault temperature [yy.mm.dd.hh.mm]	20151123:08:42	20151123:08:42	20151123:08:42	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05
Last overshoot warning temperature [yy.mm.dd.hh.mm]	20151123:08:30	20151123:08:30	20151123:08:30	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05	20161011:08:05
Data record [hh:mm]	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00

Detection of events or changes of spindle condition

EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED DURING SERVICE AT WEISS

The analysis of torque (forces), speed, temperatures and operation time on the bearings influences the life time of the bearings and makes an estimate of the rest life time and therefore an maintenance planning possible.



EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

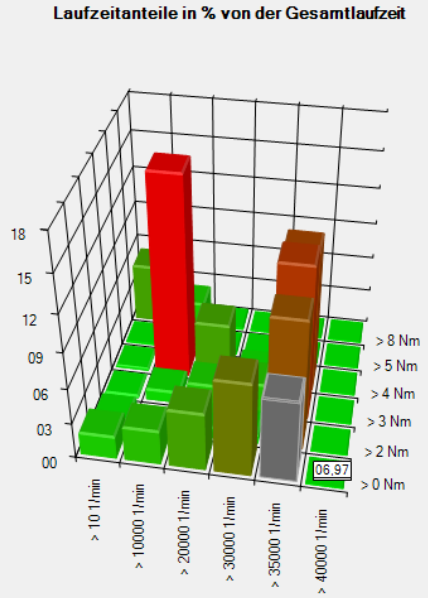
Übersicht | Matrix | Spannzustandsabfrage | Temperaturen | Ergebnisdaten tabellarisch

Drehzahlschwellen		
Anzahl	6	
Drehzahlschwelle 1	10	1/min
Drehzahlschwelle 2	10000	1/min
Drehzahlschwelle 3	20000	1/min
Drehzahlschwelle 4	30000	1/min
Drehzahlschwelle 5	35000	1/min
Drehzahlschwelle 6	40000	1/min

Drehmomentschwellen		
Anzahl	6	
Drehmomentschwelle 1	0	Nm
Drehmomentschwelle 2	2	Nm
Drehmomentschwelle 3	3	Nm
Drehmomentschwelle 4	4	Nm
Drehmomentschwelle 5	5	Nm
Drehmomentschwelle 6	8	Nm

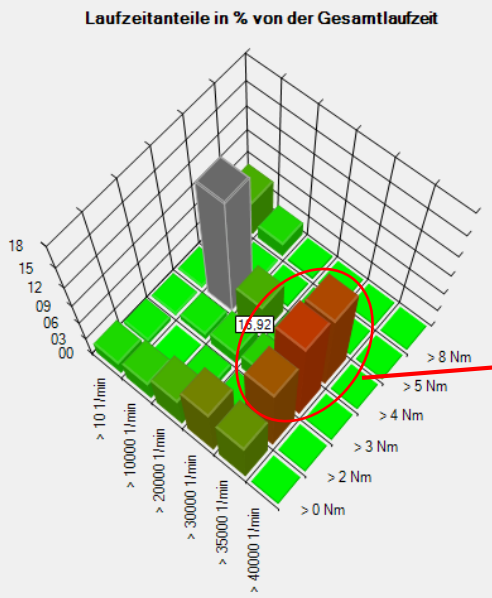
Laufzeiten		
Gesamtlaufzeit	107.07:47:22	dd.hh:mm:ss
Zeit mit Beschleunigung > 14 1/s²	09:29:42	dd.hh:mm:ss

Matrixfeld 1	2.03:15:36	dd.hh:mm:ss
Matrixfeld 2	3.04:53:24	dd.hh:mm:ss
Matrixfeld 3	5.08:09:00	dd.hh:mm:ss
Matrixfeld 4	8.13:02:24	dd.hh:mm:ss
Matrixfeld 5	7.11:24:36	dd.hh:mm:ss
Matrixfeld 6	00:00:00	dd.hh:mm:ss
Matrixfeld 7	17:56:28	dd.hh:mm:ss

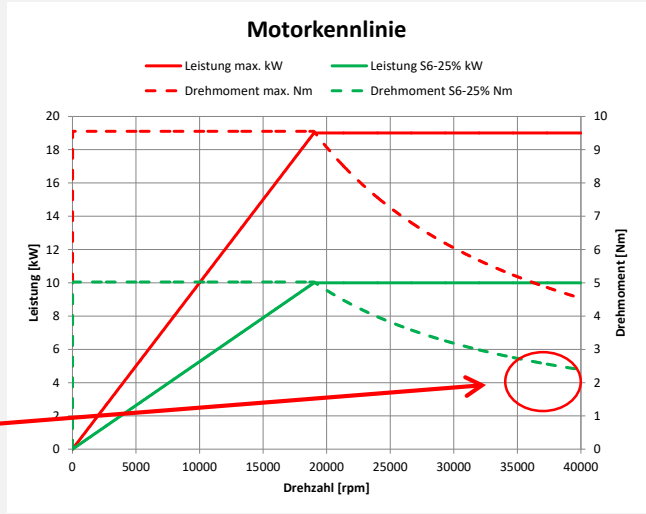


Rotation X 150 | Perspektive 0
Rotation Y 10 | Skalierung 55
Rotation Z 0

tabellarisch



Rotation X 180 | Perspektive 0
Rotation Y 40 | Skalierung 55
Rotation Z 0



Mainly operation at high speed → Possible damage process at the grease lubricated bearings

EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

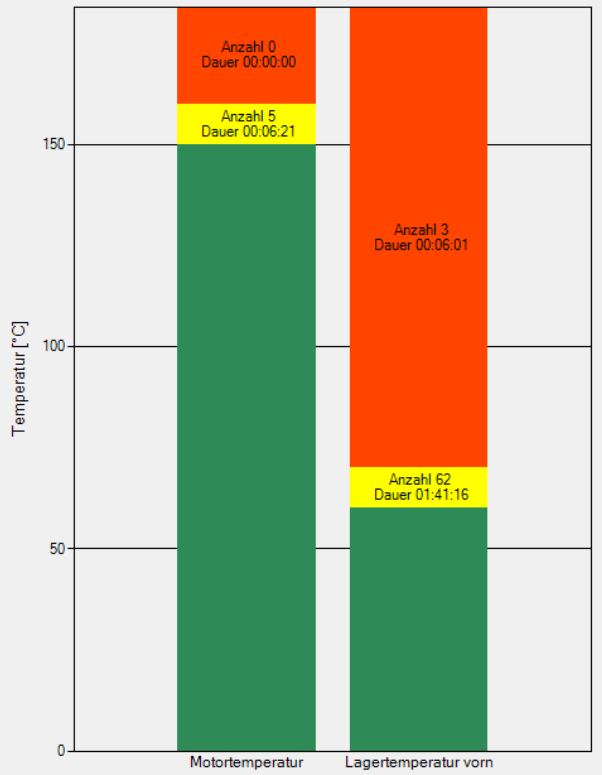
It can come to a fast ageing (bleeding) of the lubricating grease due to high temperatures at the bearing. In turn this can lead to a deficient lubrication of the bearings.

Possible necessary to doe´s:

- Changes at the processing process (cut strengths etc.)
- Optimization of the tools
- Optimization of the spindle used (e.g. store cooling.)
- …

Übersicht | Matrix | Spannzustandsabfrage | Temperaturen | Ergebnisdaten tabellarisch

PTC		
Temperaturschwelle	185	°C
Anzahl Grenzwertverletzungen	0	
Zeitdauer Grenzwertverletzungen	00:00:00	dd.hh:mm:ss
Zeitstempel letztes Ereignis		
Motortemperatur - Warnung		
Temperaturschwelle	150	°C
Anzahl Grenzwertverletzungen	5	
Zeitdauer Grenzwertverletzungen	00:06:21	dd.hh:mm:ss
Zeitstempel letztes Ereignis	05.08.2016 16:25:14	
Motortemperatur - Störung		
Temperaturschwelle	160	°C
Anzahl Grenzwertverletzungen	0	
Zeitdauer Grenzwertverletzungen	00:00:00	dd.hh:mm:ss
Zeitstempel letztes Ereignis		
Lagertemperatur vorn - Warnung		
Temperaturschwelle	60	°C
Anzahl Grenzwertverletzungen	62	
Zeitdauer Grenzwertverletzungen	01:41:16	dd.hh:mm:ss
Zeitstempel letztes Ereignis	22.01.2017 10:30:07	
Lagertemperatur vorn - Störung		
Temperaturschwelle	70	°C
Anzahl Grenzwertverletzungen	3	
Zeitdauer Grenzwertverletzungen	00:06:01	dd.hh:mm:ss
Zeitstempel letztes Ereignis	22.01.2017 10:49:17	



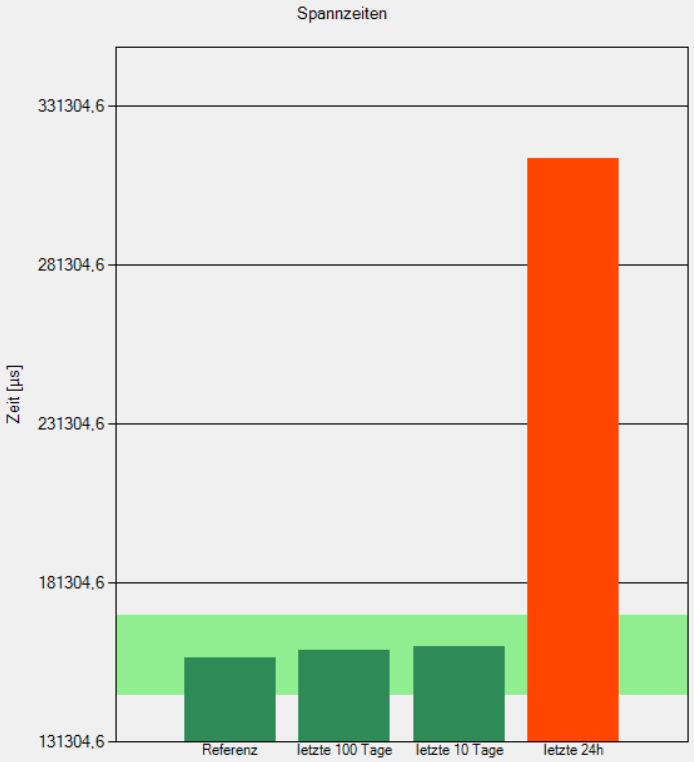
Violations of the temperature warning limit → possible failure process at the bearing

EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

During a tool change the clamping time is found out. A increase of the clamping time can point to a wear at the clamping system. For a better detection of a clamping time increase the average clamping time of the former 24 hours, former 10 days and former 100 days will be analyzed.

Übersicht | Matrix | Spannzustandsabfrage | Temperaturen | Ergebnisdaten tabellarisch

Spannerdiagnose		
gültige Spannzyklen	847514	
fehlerhafte Spann-/Lösevorgänge	174	
Drehzahlverletzungen (gespannt) ohne Werkzeug	0	
Spannvorgänge innerhalb Toleranz (ohne Werkzeug)	841549	
Spannvorgänge außerhalb Toleranz (ohne Werkzeug)	5965	
gültige Spannvorgänge (mit Werkzeug)	0	
Grenzwerte		
Maximalzeit zum Spannen	180000	µs
Drehzahlgrenze Gelöst	1	1/min
Drehzahlgrenze Spannend	0	1/min
Drehzahlgrenze Lösend aus Zustand 'Gespannt mit Werkzeug'	0	1/min
Drehzahlgrenze Lösend aus Zustand 'Gespannt ohne Werkzeug'	0	1/min
Drehzahlgrenze Gespannt mit Werkzeug	44000	1/min
Drehzahlgrenze Spannend ohne Werkzeug	0	1/min
Drehzahlgrenze Gespannt ohne Werkzeug	1000	1/min
Referenzspannzeiten		
Minimalwert	145894	µs
Maximalwert	170811	µs
Mittelwert	157544	µs
Ø Spannzeiten		
Mittelwert bei Betrieb (24 h)	314720	µs
Mittelwert bei Betrieb (10 Tage)	160938	µs
Mittelwert bei Betrieb (100 Tage)	159938	µs
Referenzlösezeiten		
Minimalwert	0	µs



Fast increase of clamping time → broken spring of the clamping system

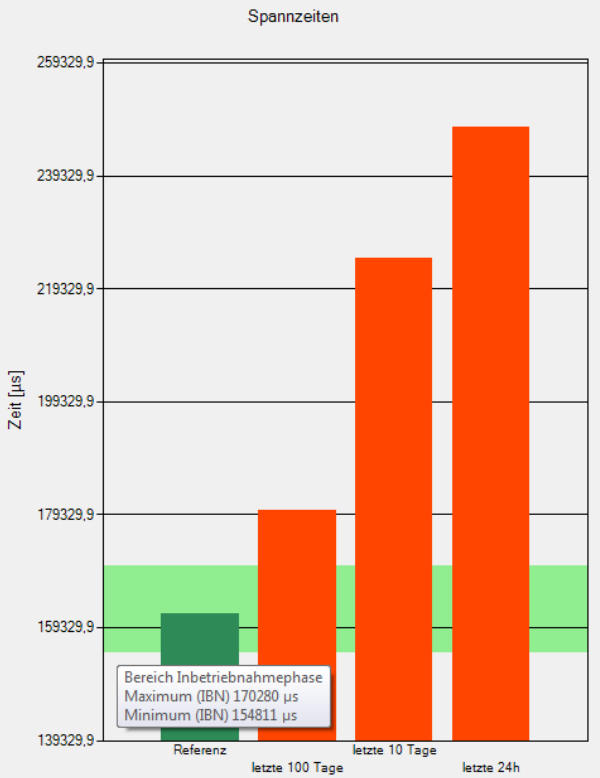
EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

A tool clamping system contains a spring column, whose spring load keeps the tool in the tool interface of the spindle shaft. The spring column is executed for a defined number of clamping cycles and wears out about the number of clamping cycles.
The digitalized spindle evaluates the used clamping time of each clamping cycle. At a loss of the spring load or of an increase of friction this time will change.

For a better detection of a clamping time increase the average clamping time of the former 24 hours, former 10 days and former 100 days will be analysed.

Übersicht | Matrix | Spannzustandsabfrage | Temperaturen | Ergebnisdaten tabellarisch

Spannerdiagnose		
gültige Spannzyklen	1578940	
fehlerhafte Spann-/Lösevorgänge	243	
Drehzahlverletzungen (gespannt) ohne Werkzeug	0	
Spannvorgänge innerhalb Toleranz (ohne Werkzeug)	1573469	
Spannvorgänge außerhalb Toleranz (ohne Werkzeug)	5471	
gültige Spannvorgänge (mit Werkzeug)	1347810	
Grenzwerte		
Maximalzeit zum Spannen	210000	µs
Drehzahlgrenze Gelöst	1	1/min
Drehzahlgrenze Spannend	0	1/min
Drehzahlgrenze Lösend aus Zustand 'Gespannt mit Werkzeug'	0	1/min
Drehzahlgrenze Lösend aus Zustand 'Gespannt ohne Werkzeug'	0	1/min
Drehzahlgrenze Gespannt mit Werkzeug	40000	1/min
Drehzahlgrenze Spannend ohne Werkzeug	0	1/min
Drehzahlgrenze Gespannt ohne Werkzeug	1000	1/min
Referenzspannzeiten		
Minimalwert	154811	µs
Maximalwert	170280	µs
Mittelwert	161841	µs
Ø Spannzeiten		
Mittelwert bei Betrieb (24 h)	248014	µs
Mittelwert bei Betrieb (10 Tage)	224810	µs
Mittelwert bei Betrieb (100 Tage)	180017	µs
Referenzlösezeiten		
Minimalwert	0	µs



Slowly increase of clamping time → damage process or wear of clamping system parts

EXEMPLARY EVALUATION OF THE DATA OF THE DIGITIZED SPINDLE. EXECUTED BY THE CUSTOMER OR DURING SERVICE AT WEISS

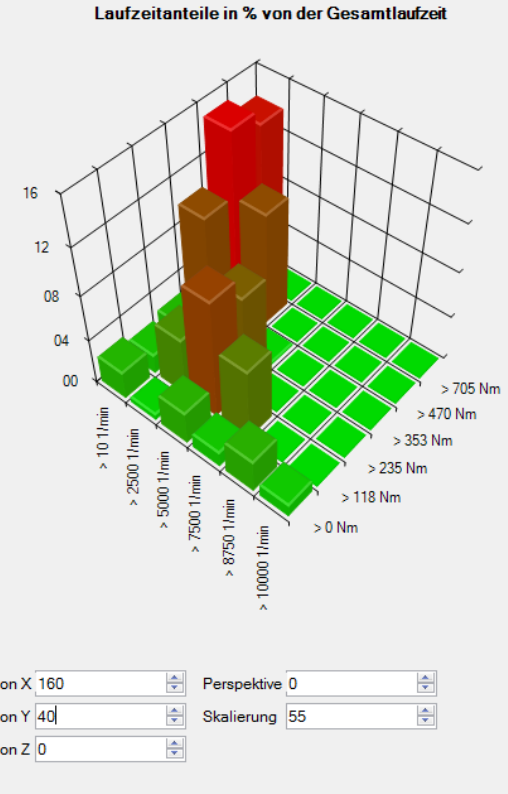
Übersicht | Matrix | Spannzustandsabfrage | Temperaturen | Ergebnisdaten tabellarisch

Drehzahlschwellen		
Anzahl	6	
Drehzahlschwelle 1	10	1/min
Drehzahlschwelle 2	2500	1/min
Drehzahlschwelle 3	5000	1/min
Drehzahlschwelle 4	7500	1/min
Drehzahlschwelle 5	8750	1/min
Drehzahlschwelle 6	10000	1/min

Drehmomentschwellen		
Anzahl	6	
Drehmomentschwelle 1	0	Nm
Drehmomentschwelle 2	118	Nm
Drehmomentschwelle 3	235	Nm
Drehmomentschwelle 4	353	Nm
Drehmomentschwelle 5	470	Nm
Drehmomentschwelle 6	705	Nm

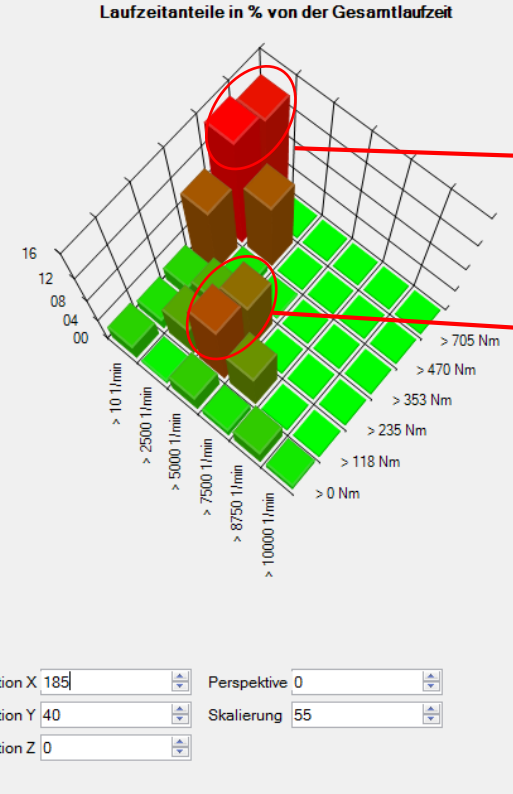
Laufzeiten		
Gesamtlaufzeit	859.14:37:27	dd.hh:mm:ss
Zeit mit Beschleunigung > 14 1/s²	09:29:42	dd.hh:mm:ss

Matrixfeld 1	21.07:00:43	dd.hh:mm:ss
Matrixfeld 2	4.22:50:24	dd.hh:mm:ss
Matrixfeld 3	24.18:12:00	dd.hh:mm:ss
Matrixfeld 4	11.21:12:58	dd.hh:mm:ss
Matrixfeld 5	24.18:12:00	dd.hh:mm:ss
Matrixfeld 6	9.21:40:48	dd.hh:mm:ss
Matrixfeld 7	14.20:31:12	dd.hh:mm:ss

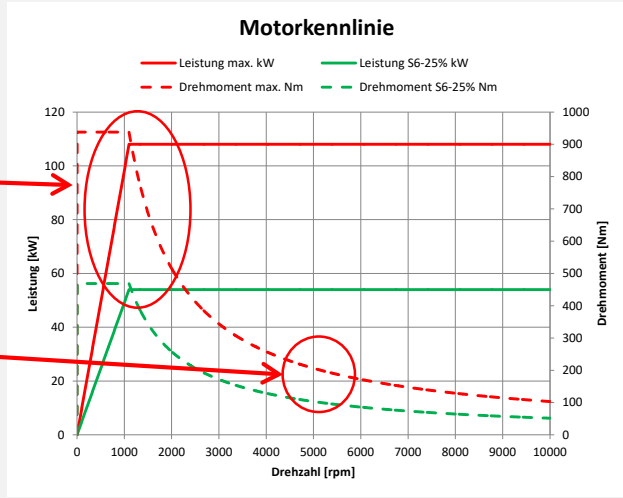


Rotation X 160 Perspektive 0
Rotation Y 40 Skalierung 55
Rotation Z 0

tabellarisch



Rotation X 185 Perspektive 0
Rotation Y 40 Skalierung 55
Rotation Z 0



Conclusions can be drawn about the load of the spindle bearing and the thermal load of the motor from the running time of the spindle with respect to predefined speed ranges and torque ranges.

Great load in the area to nominal speed → strong thermal use of the motor.