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PRACTICAL EXPERIENCE WITH BELTGENIUS

MONITORING AND EVALUATION OF THE OPERATING BEHAVIOR OF A CONVEYOR SYSTEM IN A CHILENIAN COPPER MINE WITH A DIGITAL TWIN

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Structure of the Presentation

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Brief profile of the tested conveyor system

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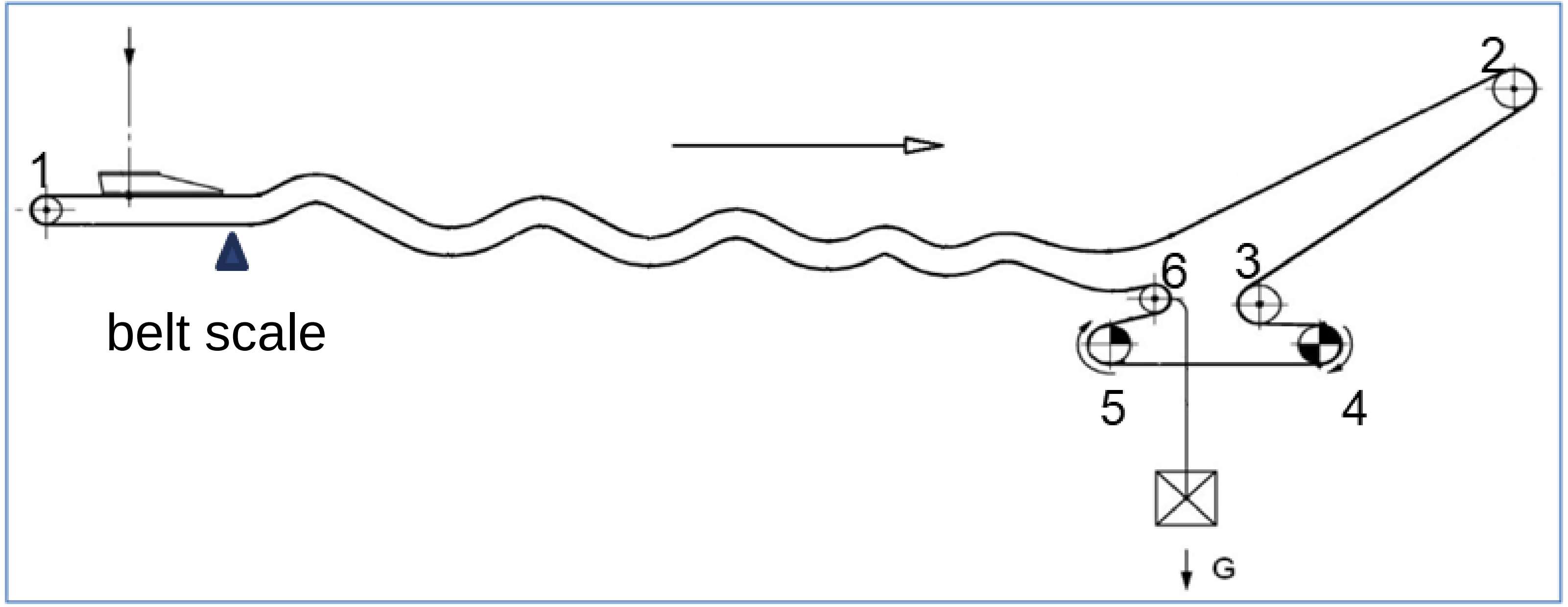

- Axle distance 3,6 km
- Nominal capacity 7.000 tph
- 3x1.250 kW Slipring motors @pulleys 4 & 5
- 6 m/s belt speed
- Steelcord belt tensioned by gravity take-up @pulley 6

Description of the procedure using the digital twin

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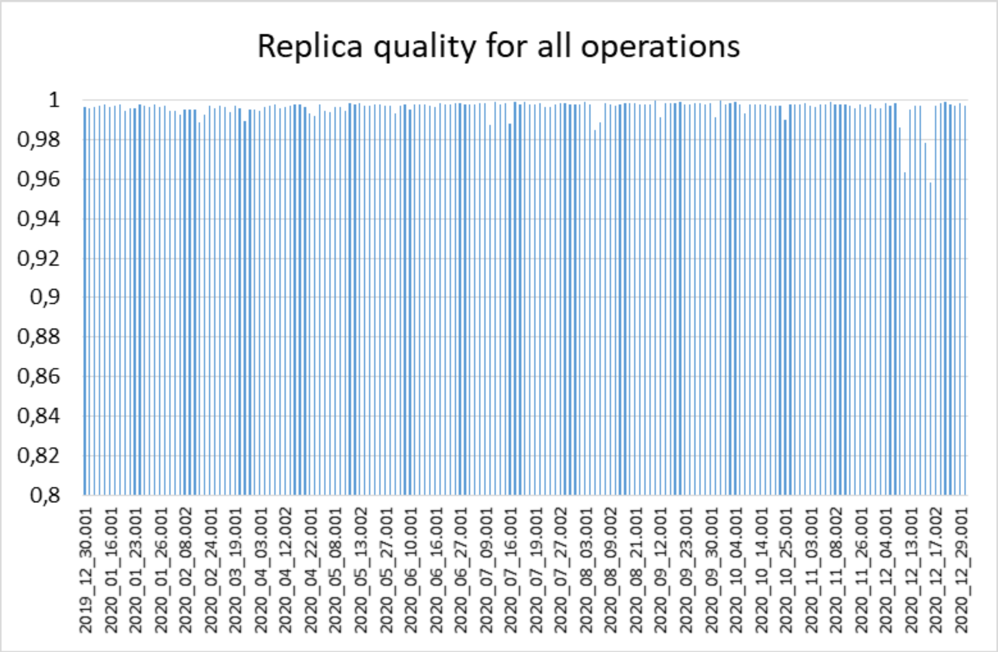

$$\text{Replica quality} = 1 - \frac{\sum_1^n (P_{calc} - P_{mess})^2}{\sum_1^n {P_{mess}}^2}$$

- BeltGenius is an analytical calculation model of the movement resistances and the resulting belt tension forces
- The adaptation to reality is carried out by creating a structure data set and determining the appropriate status parameters
- The quality criterion is the deviation between the measured and calculated motor power
- The accompanying simulation of the system with current operating data (online version) or - as in this case - the recalculation of a specified period (offline version) is possible.

Selected evaluations for a one time period

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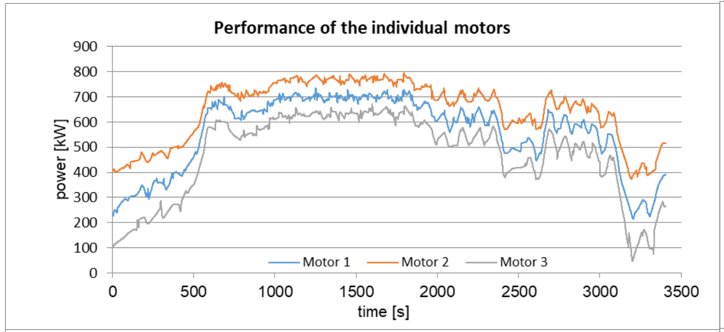

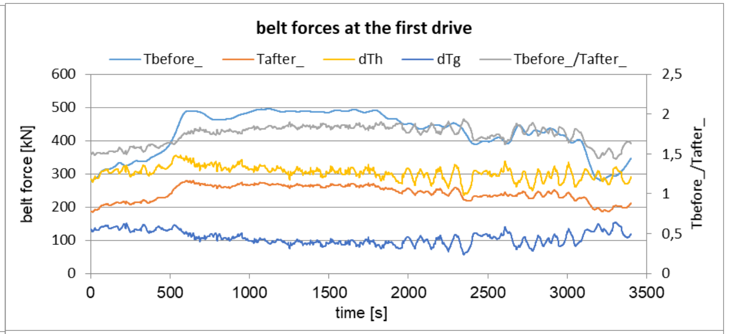

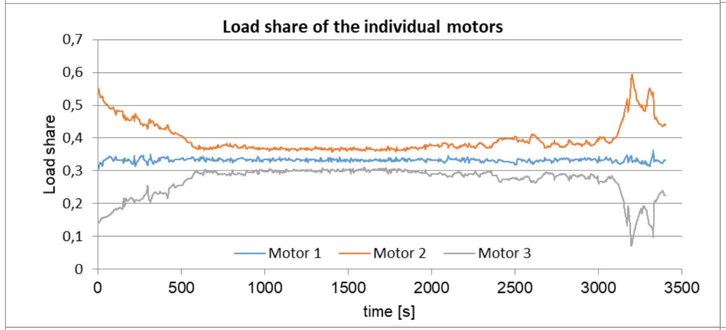

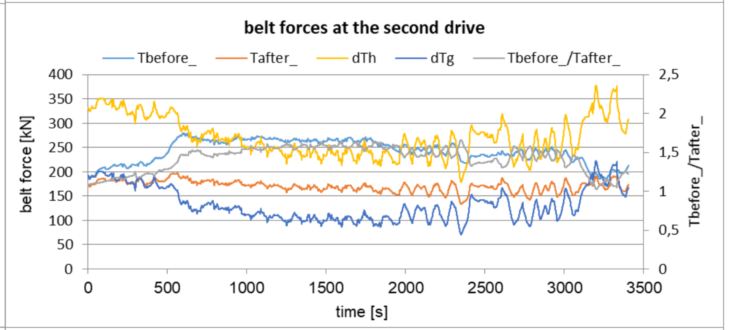

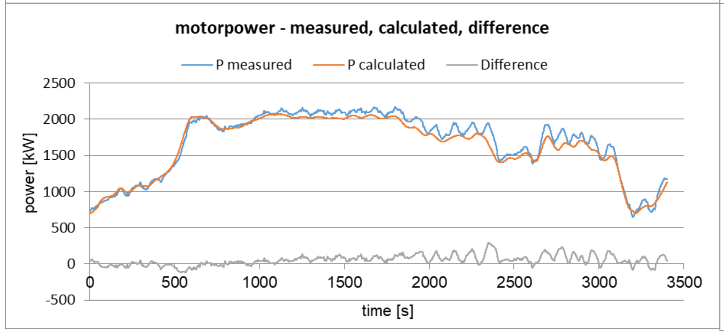

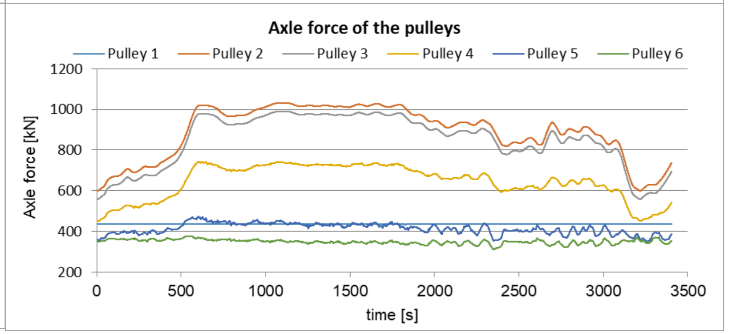

- In the 12 months, the conveyor was started up 189 times
- The duration of these time periods was between 382 seconds and 287 hours, average: 43.35 hours
- The calculation results for each time period are stored in topic-specific files
- This slide shows a selection of evaluations for a single time period

General assessment of the system

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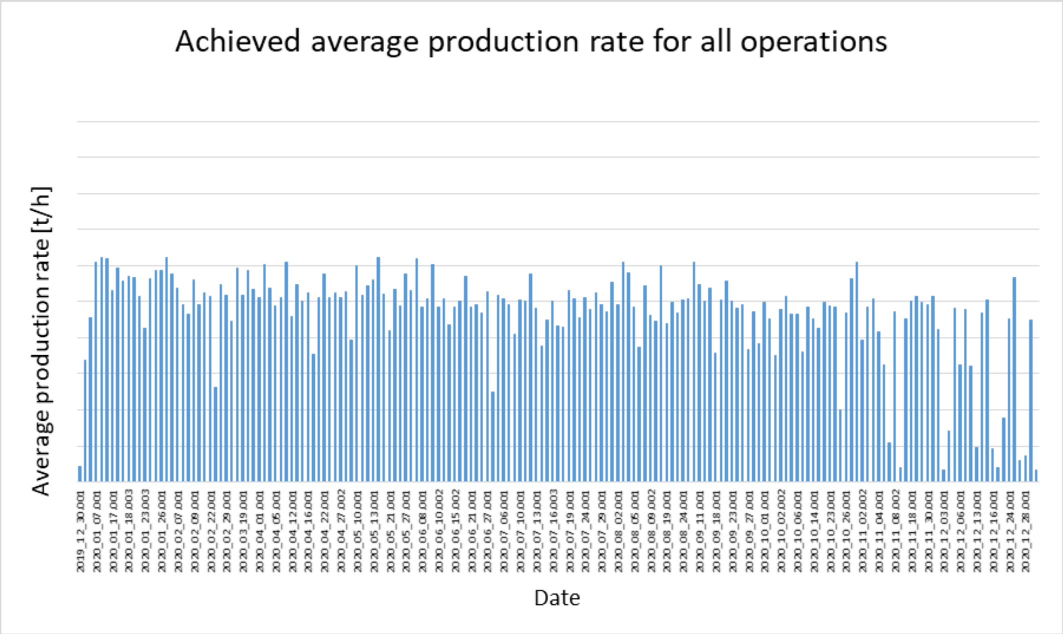
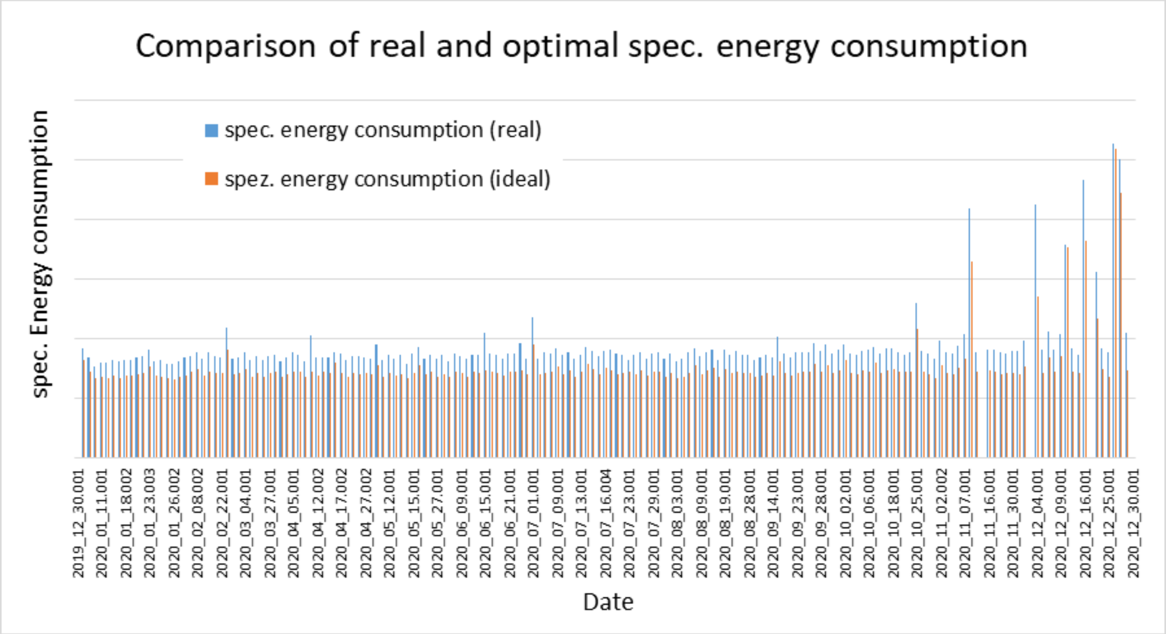




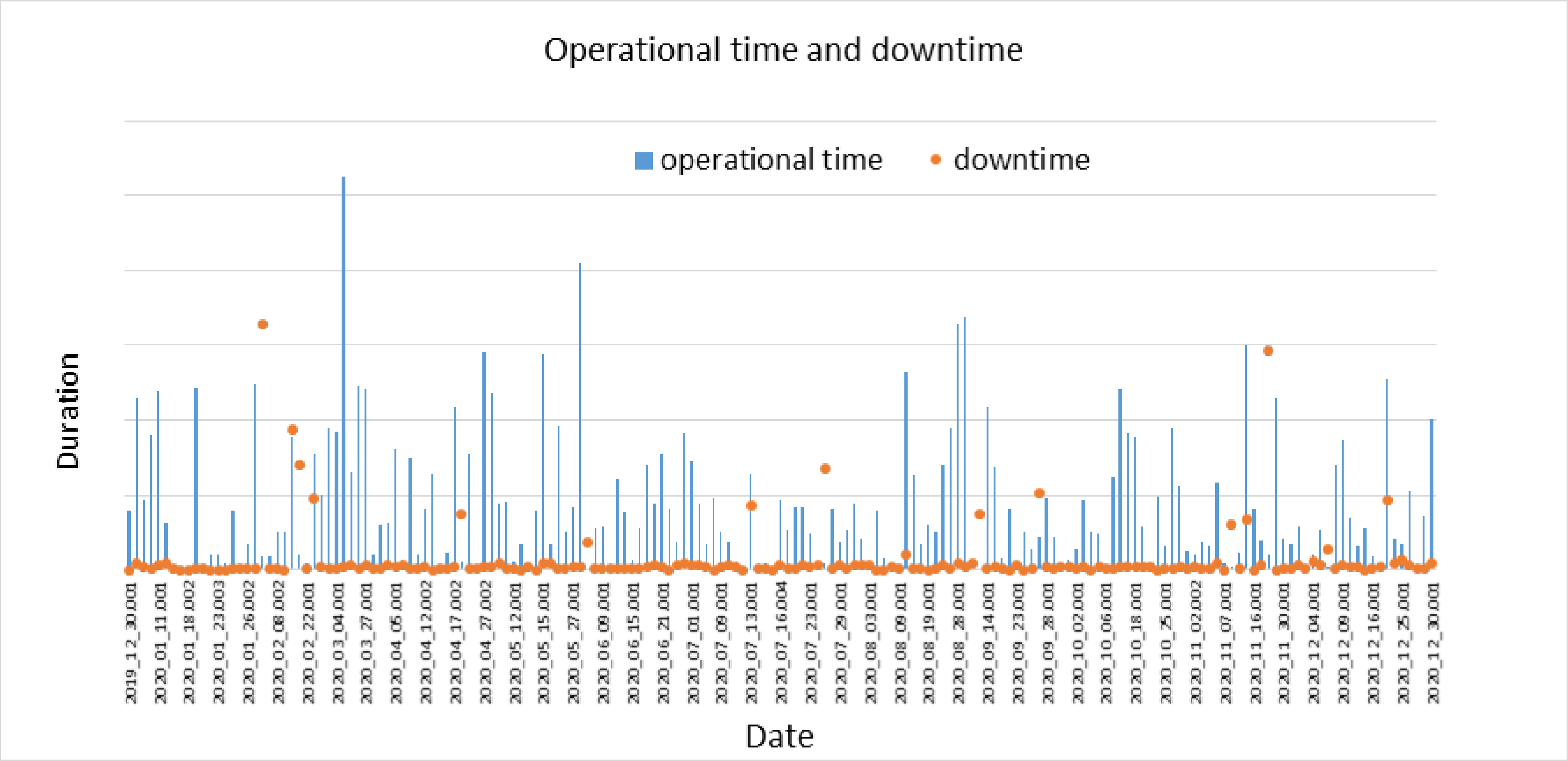
Key figures for utilization and efficiency of the conveyor system:

- Duration of the individual operating times
- Downtime between operating times
- replica quality
- Average flow rate
- specific energy consumption per ton - real and ideal
- Absolute energy consumption real and ideal

Usage rate : 86,82 %
(operating time / calendar time)

Load rate: 71,8 %
(average delivery rate / nominal delivery rate)

General assessment of the system



- The graphic shows the individual operating times as well as the duration of the downtimes (between 6 minutes and 6 days, 19 hours and 40 minutes, on average 6 h 40 m) in between
- The dozen or so shutdowns that lasted longer than a day are easy to see

Visualization of load and belt force along the conveyor

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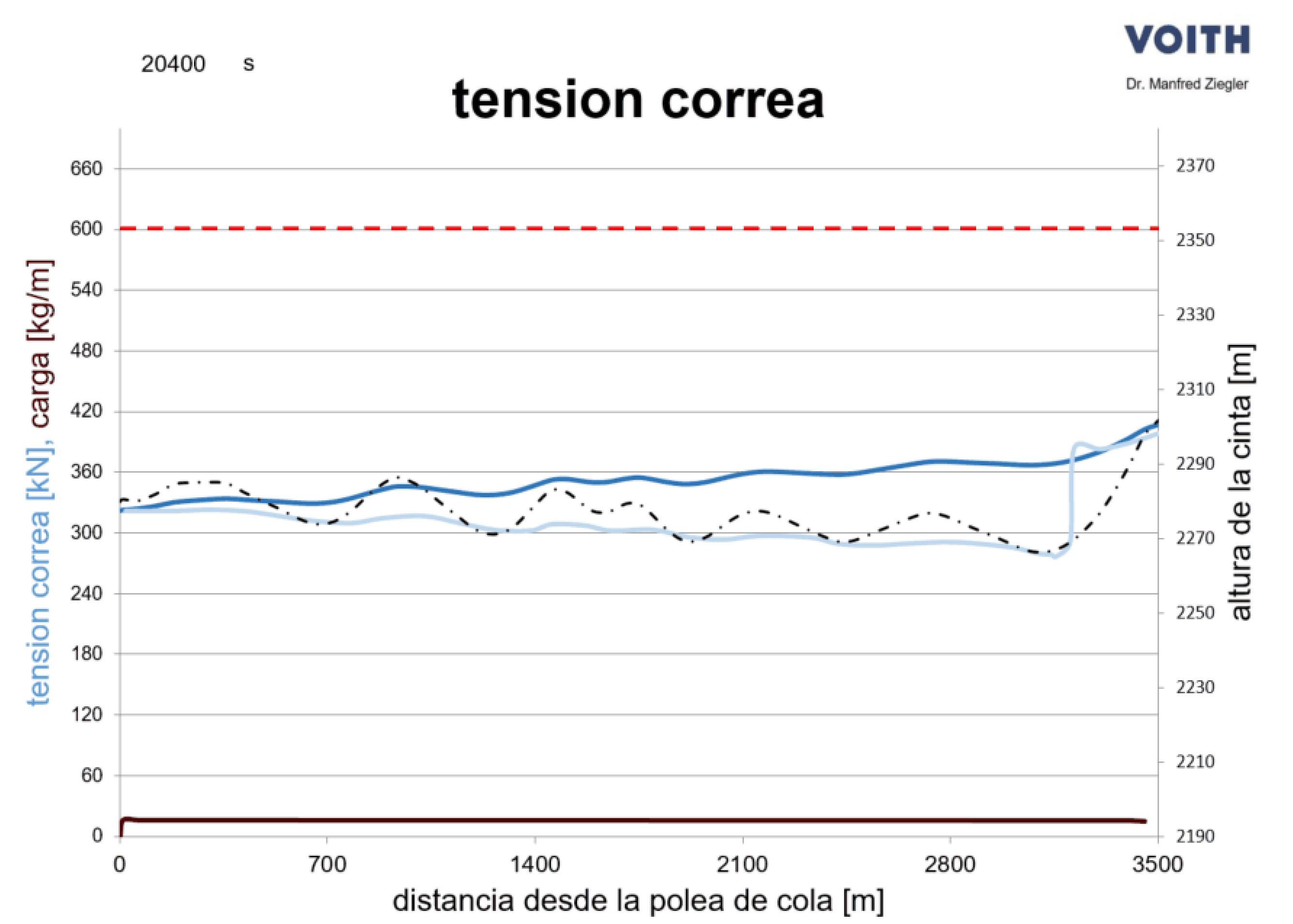
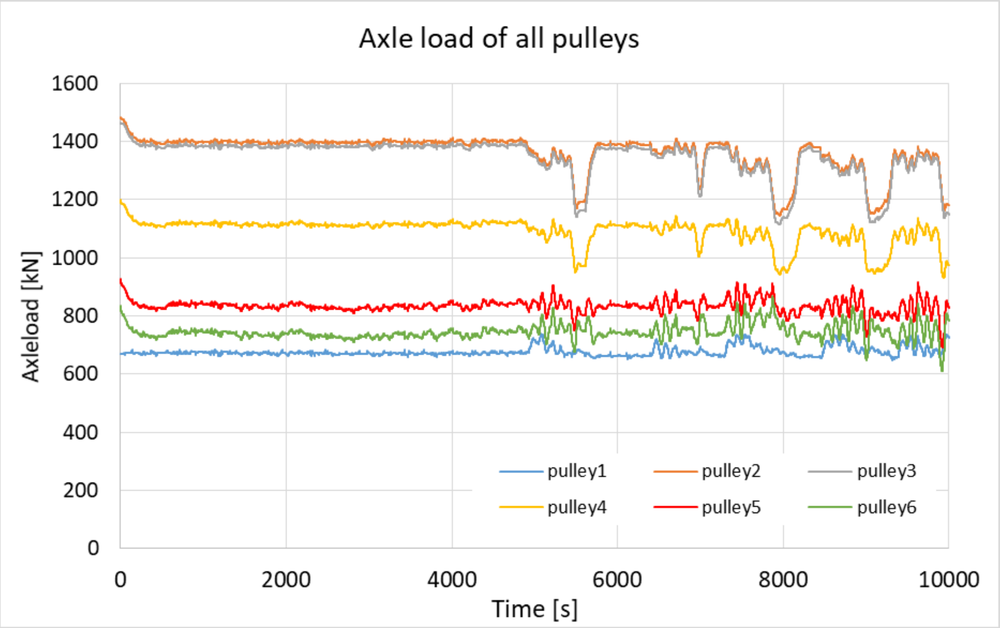
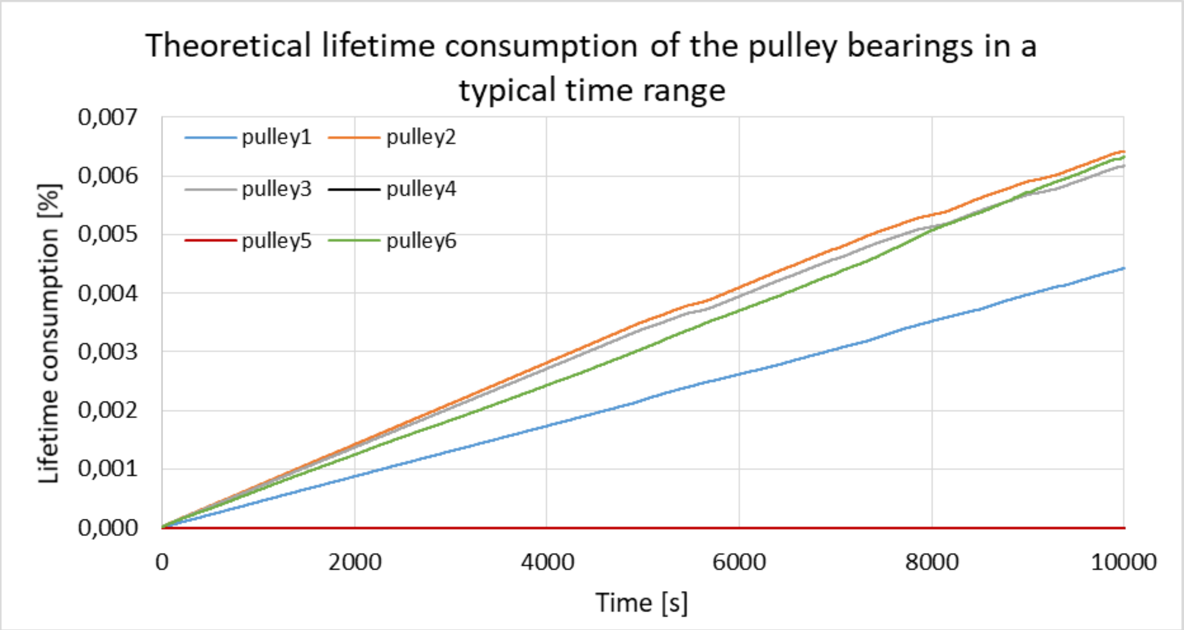


- The system evaluates permanently the load and the belt force along the whole conveyor
- Therefore it is possible, to determine the load spectrum of all key components: belts, splices, idlers, pulleys, gearboxes and motors

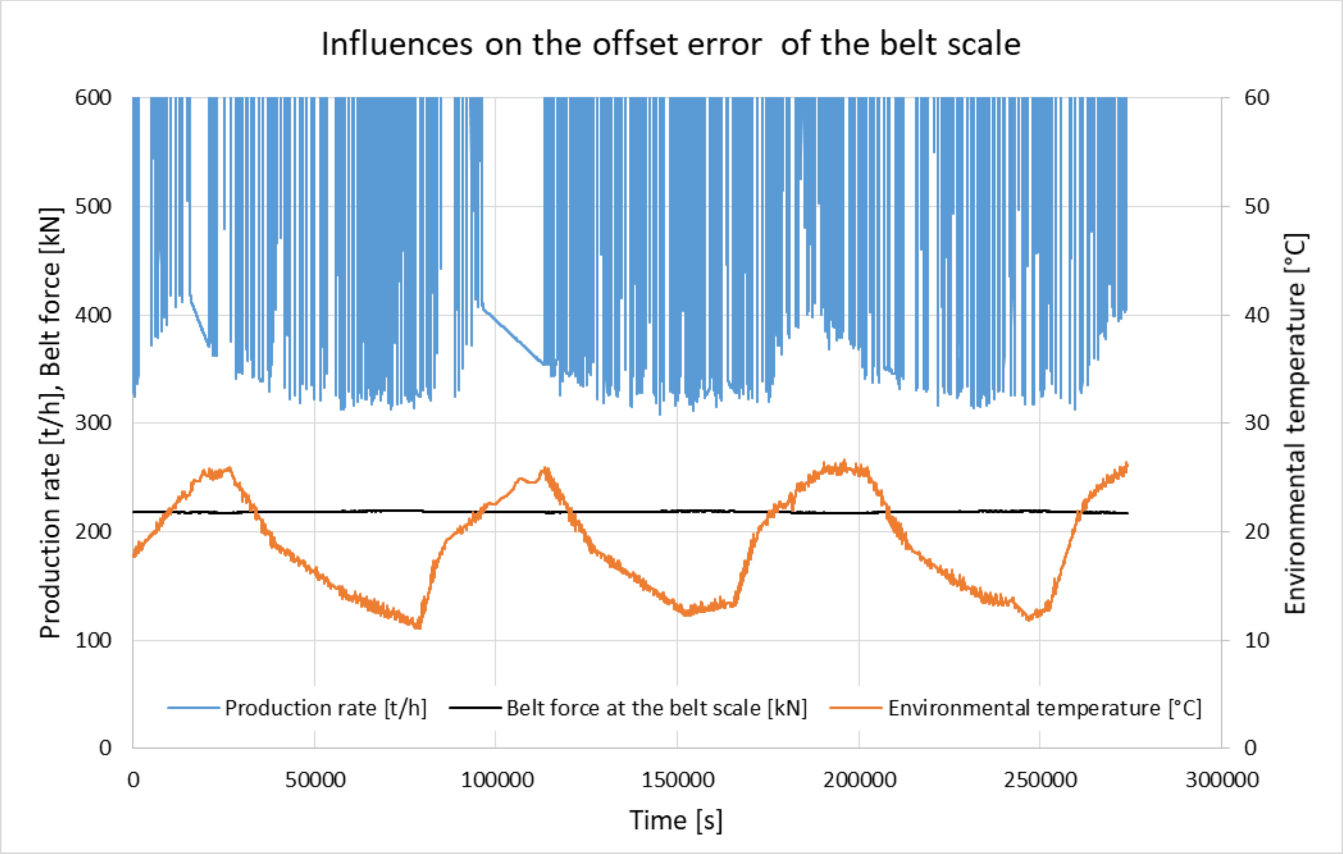
Estimation of the component service life





- BeltGenius can seamlessly record the relevant forces or torques as well as paths and angles of rotation for all moving parts
- If the relationship between stress and wear and tear is known, life predictions can be generated automatically
- This example shows the theoretical service life estimation of the pulley bearings from the axle load curve of these six pulleys. The calculated service life for the respective bearing load can be calculated for every single second
- The summation of the reciprocal values then supplies the lifetime consumption for this time range

Noticeable deviations
Measuring errors of the belt scale



- The belt scale has an offset between 300 and 420 t/h, which seems to be affected by the ambient temperature: the higher the temperature, the higher the offset
- This error is in the range of a few percent of the nominal flow rate
- The error can be larger or smaller at higher delivery rates
- The local belt tension has no influence on the offset error. So there is no misalignment of the belt scale

Noticeable deviations

Poor loadsharing of the drives

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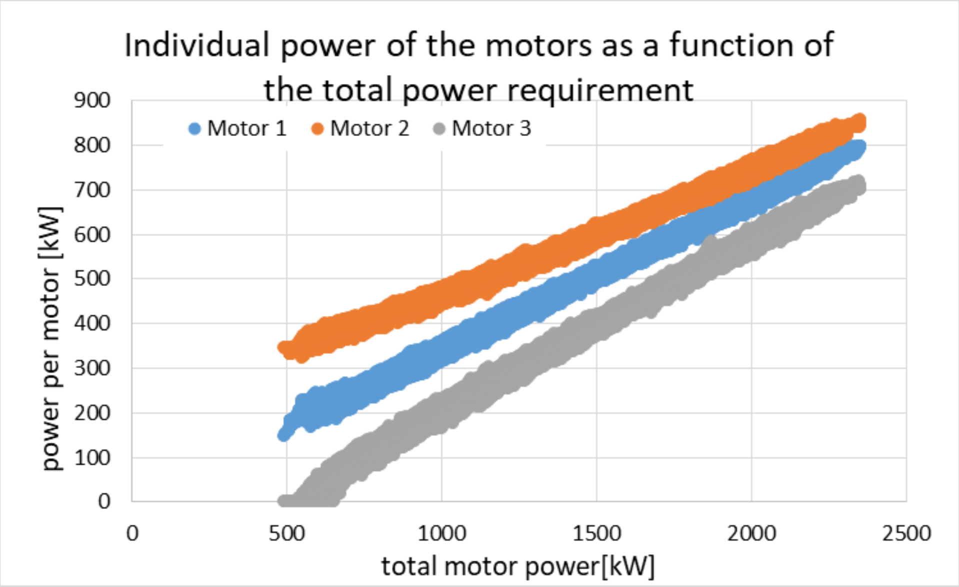
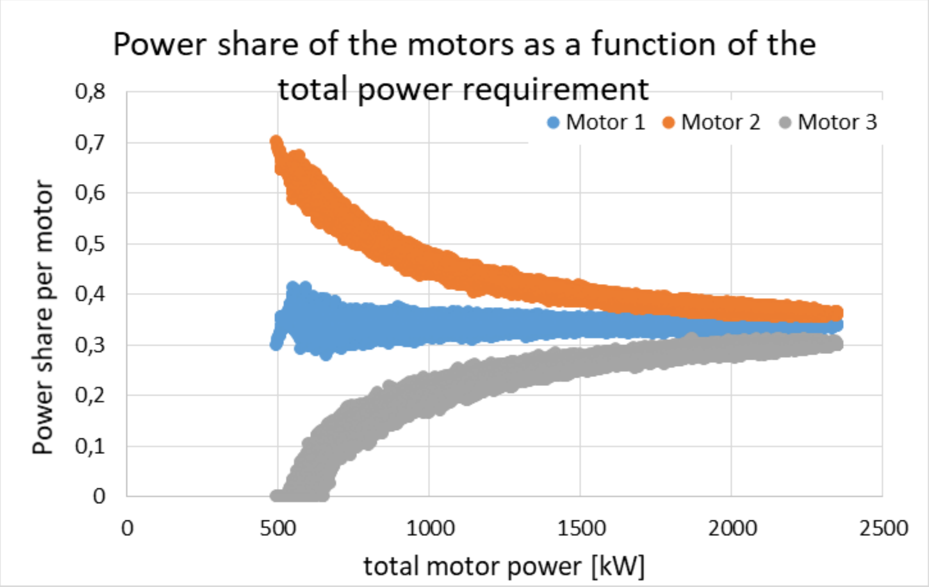




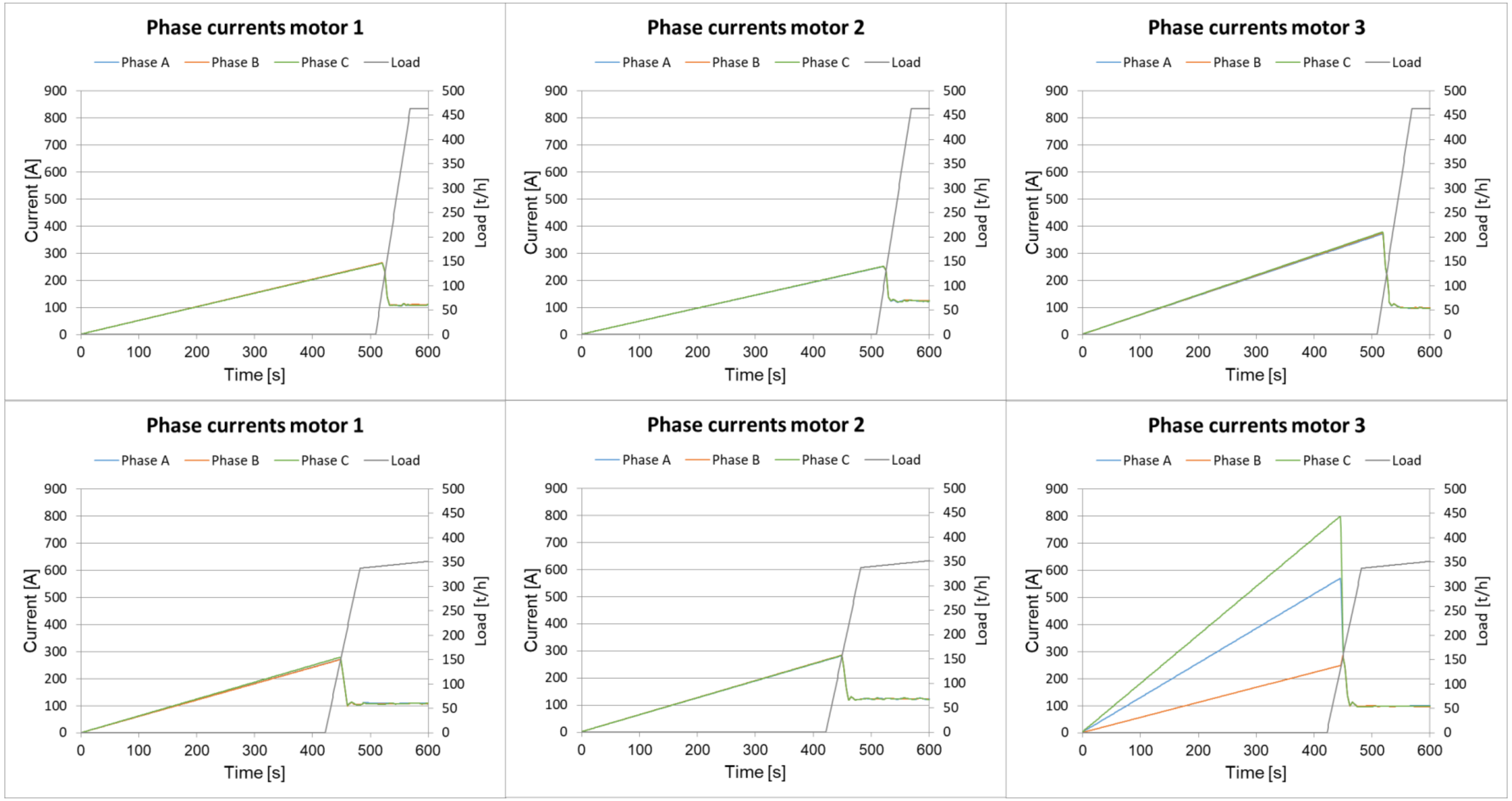
Over the full 12 months, the power distribution of the three motors was as follows:

- average power motor 1: 560.55 kW, corresponds to 33.73%
- average power motor 2: 636.58 kW, corresponds to 38.31%
- average power motor 3: 464.65 kW, corresponds to 27.96%

The power distribution depends on the current total power requirement

Noticeable deviations

Malfunction of the liquid starter

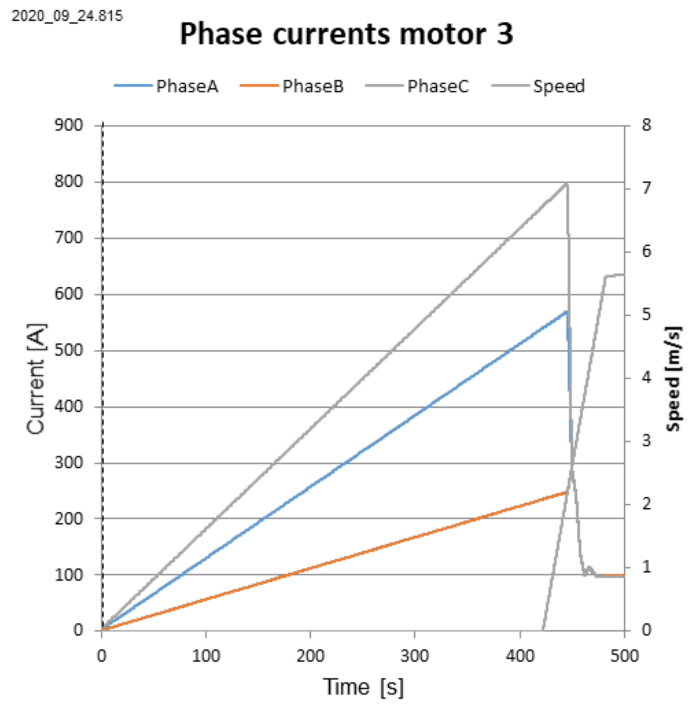


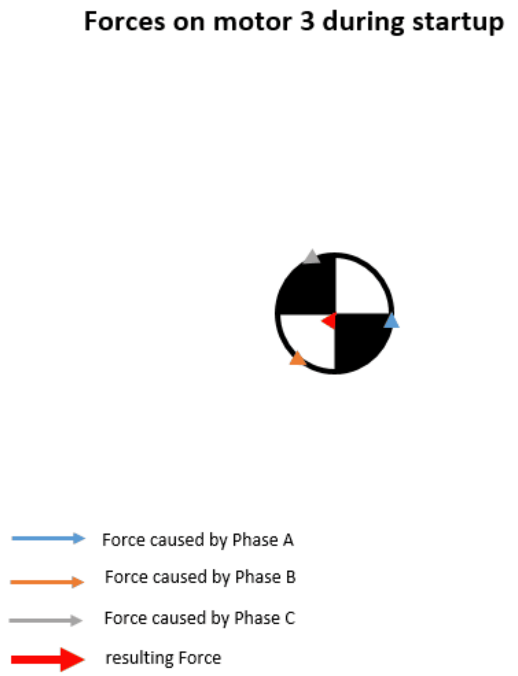
The stator currents of the three phases are practically the same for every motor.

However, in some ramp-ups, strong deviations between the phases occurred.

This affected all motors three or four times within the 12 months.

Noticeable deviations
Malfunction of the liquid starter





- Each phase creates a force on the rotor and an opposing force on the stator according to its current.
- These three forces are at an angle of 120° to each other.
- As long as all three phases have the same current, the forces are equal and only produce torque but no resultant force.
- Asymmetric phase currents, on the other hand, cause a considerable eccentric force.
- The direction of this resultant force changes with rotor angle.
- Since all three drives exhibit this effect from time to time, damage to the drives is very likely as long as the liquid starter causes this eccentricity

Procedure for optimal operation using a digital twin

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- "Anchoring": setting up the digital twin, adapting to the real state using measurement data and optimizing the state parameters, "basic assessment of the system" --> classic consulting with better means
- Definition of critical limit values: For each value (real or virtual, resp. measured or calculated) limit values (lower limit, upper limit, permissible volatility) must be defined depending on the respective operating mode (starting up, stationary operation and shutdown)
- Preliminary definition of the deviation messages: Which plain text message should be generated for each of the possible limit value violations?
- Agreement with the operator as to who receives which error message and what measures are then taken
- Optimization and maintenance of the system: research into the causes of detected deviations, if necessary adjustment of the critical limit values, the respective addressees of the deviation report and the measures to be taken --> iteration of the last three steps

Monitoring of energy efficiency using a digital twin

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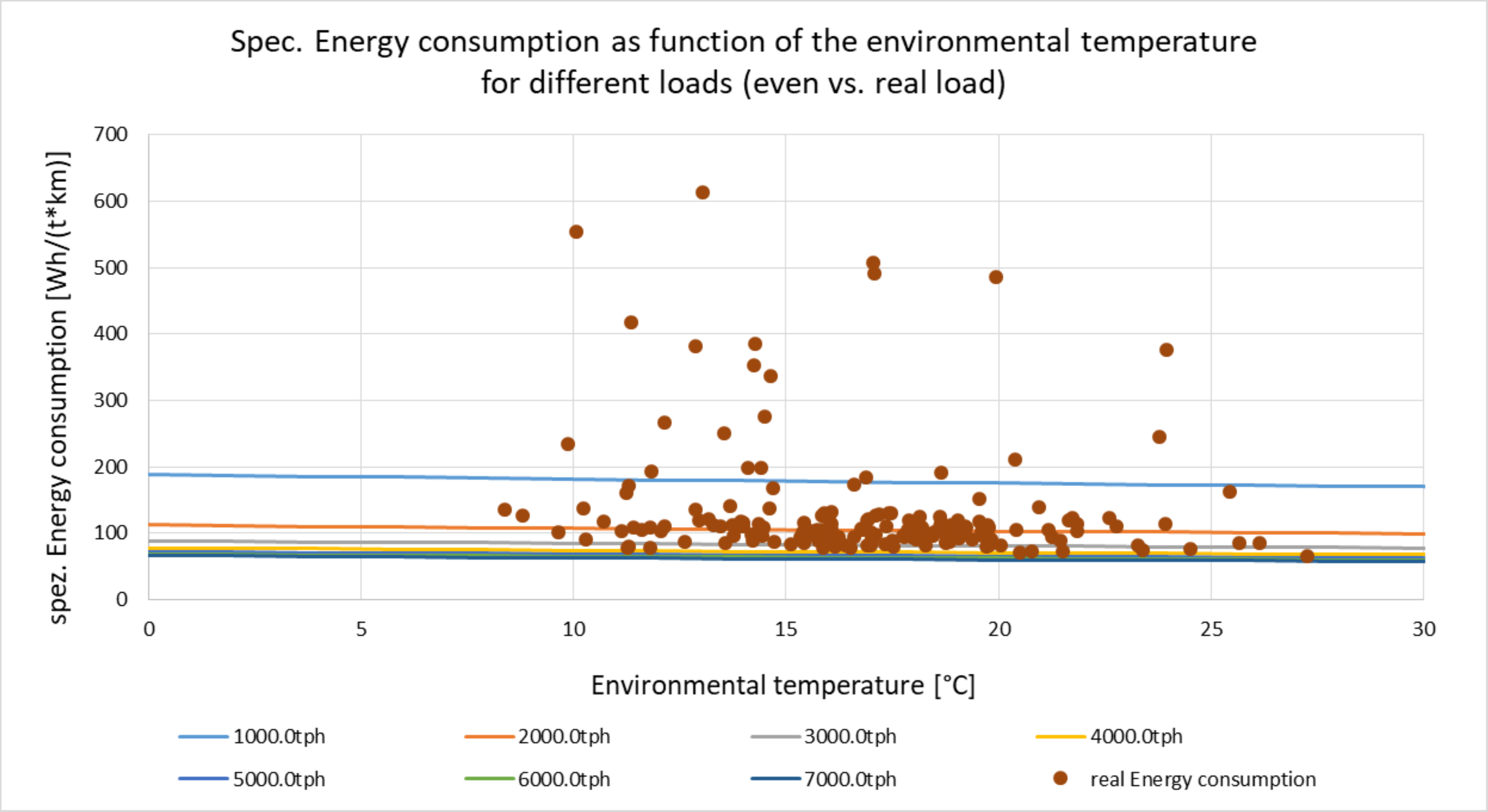

In order to be able to compare systems with each other in terms of their energy efficiency, we need a general accepted standard for the calculation of a suitable KPI.

BeltGenius can already be used to give the operator information

- how efficient his system is under different operating conditions
- how efficiently he runs his system in practice.

Summary

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- BeltGenius provides a quick overview of the condition, efficiency and utilization of the system
- Starting points for improvement can be revealed and quantified
- For the expert who wants to optimize a system, this is a much more powerful tool than the usual calculation and simulation tools
- The challenge is to turn an initially "passive" digital twin into an active monitoring system that automatically detects and reports deviations and initiates the necessary measures
- The approach of using a digital twin to optimize the operation and maintenance of a plant is particularly lucrative for high-quality capital goods that are built in series and is therefore already well advanced in some areas
- In comparison, we are still in the early stages of bulk material handling technology, since each system is individual and economies of scale are slower to set in
- Nevertheless, the effort is worth it, because the improvements and savings that are possible with it cannot be achieved in the conventional way
- In addition, the expertise for optimal operation and maintenance of conveyor systems can be assumed by fewer and fewer operators. A monitoring system for conveyor systems is needed that increasingly replaces this expert knowledge
- However, training, maintaining and expanding such a system requires close cooperation with the operator.

Thank you very much for your attention!

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