Evaluation of the remaining life time considering operation loads and the state of corrosion protection

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Motivation

For the economic operation of offshore wind power plants an operating time of more than 20 years is required. Mechanical and corrosive loads are particular challenges in terms of ensuring a sufficient lifetime. A detailed knowledge of the current status of the structure, their components and the corrosion protection system may help to reduce costs and increase safety and reliability.

Concerning corrosion, structure surfaces in atmospheric, splash and tidal zone are protected by organic coatings. Even theses coatings underlie degradation processes which may lead to a loss of the protection properties. Therefore, a monitoring or at least detection system for coating performance is useful for the operation of power plants.

Steel support structures under complex loading conditions

Fraunhofer IWES

The main objective was the determination of the remaining fatigue life on the basis of measured operating load data. The calculation process of Fig. 01 was implemented in a MATLAB based analysing tool. The current state of degradation of fatigue critical details can be estimated on bases of normative S-N curves.

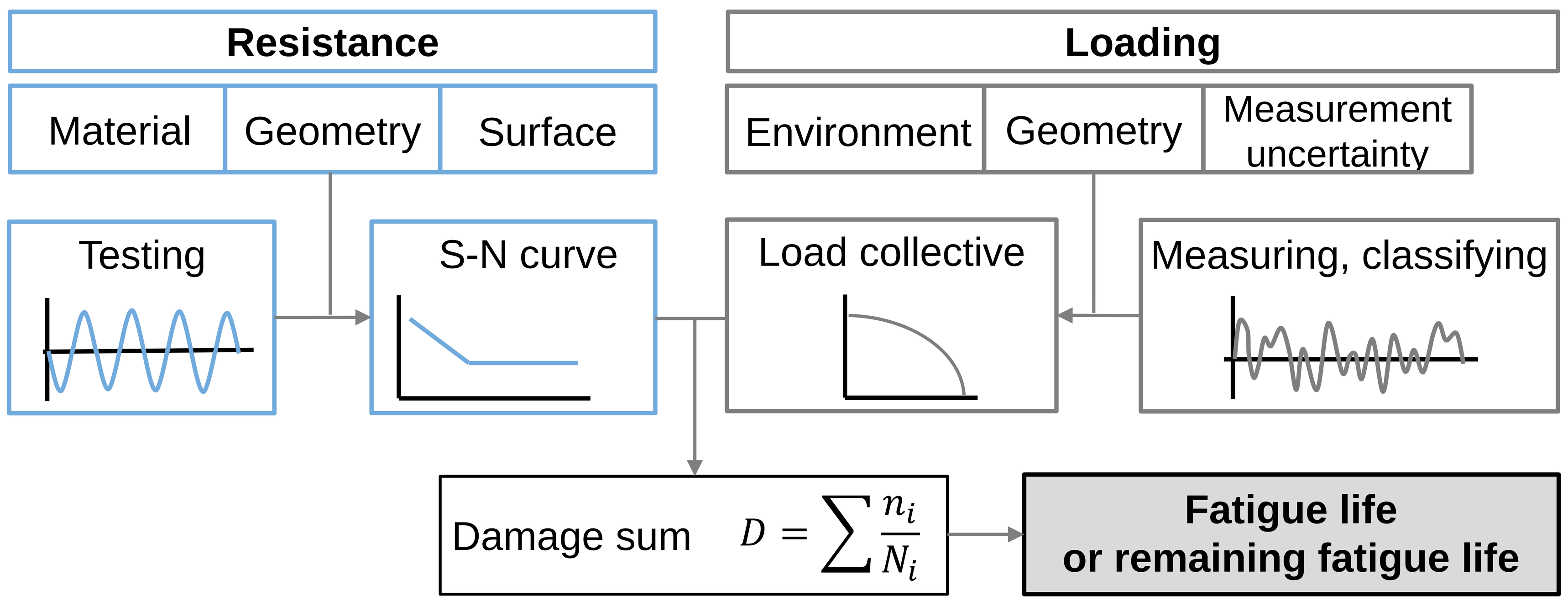

Fig. 01: Process diagram for the calculation of the remaining fatigue life

In the absence of measuring data of the offshore test field an existing fatigue test of a recently finished research project on a tubular joint at the span of the Test Center for Support Structures has been used in order to generate representative stress histories. The test setup is illustrated in Fig. 02.

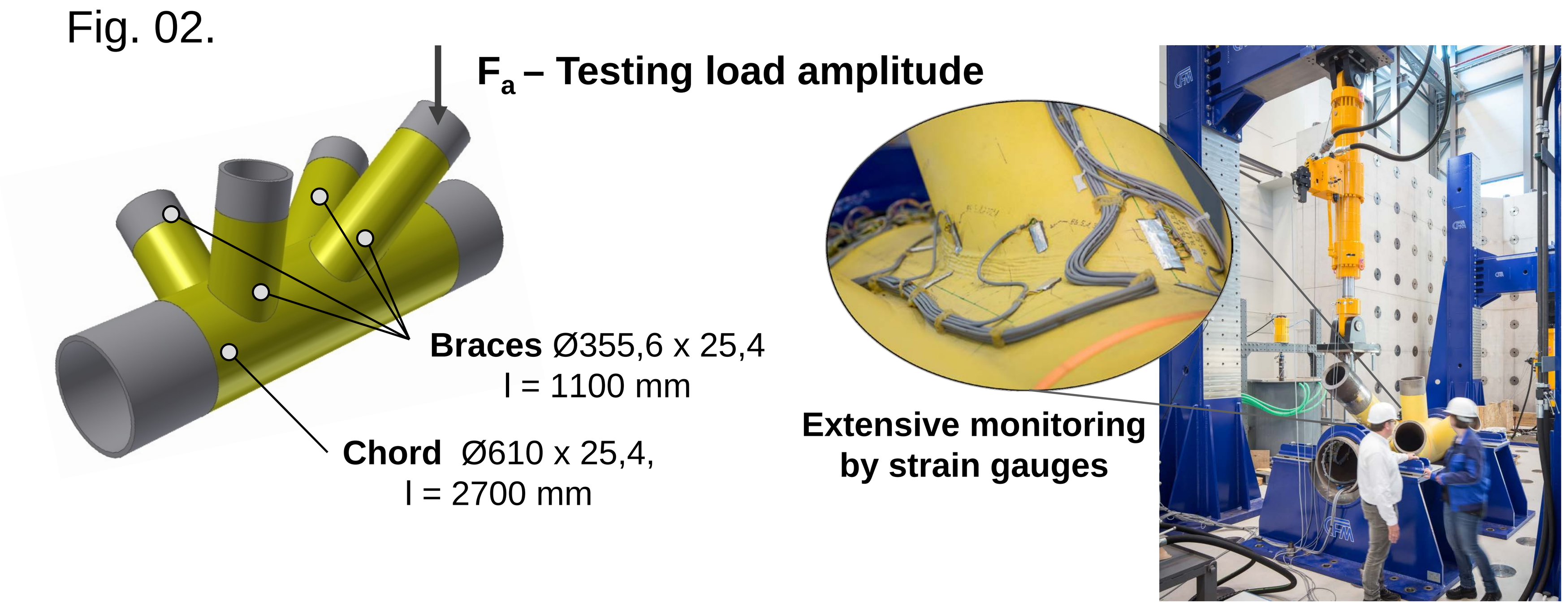

Fig. 02: Tubular joint with dimensions and fatigue test setup of the project KOWIND [1]

For the hot spot at the crown heel of the chord the strain data has been evaluated for determining the actual damage sum. The results are presented in Fig. 03. Considering the hot spot stress range and the S-N curve T according to DIN GL RP-C203 a current damage sum $D_{10\ min}$ of $3.9 \cdot 10^{-6}$ is calculated. This means after a period of 5 years a damage sum D of 1.0 is reached when assuming the same load conditions.

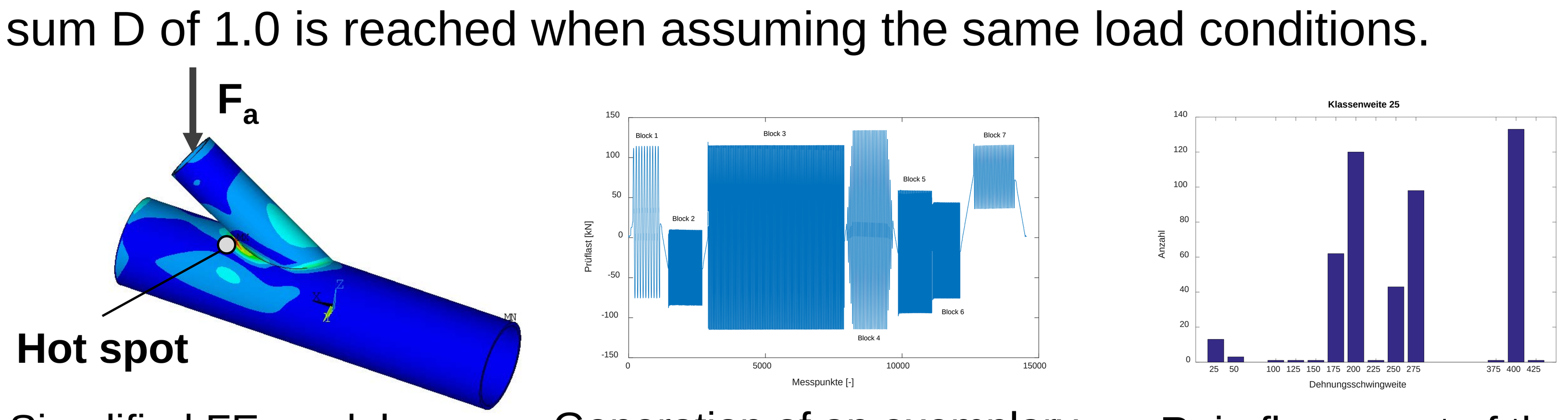

Fig. 03: Exemplary results

Conclusions

The MATLAB based analysing tool provides results fast and reliably. Linking this tool to the measurement database may be an useful addition for future activities.

References

[1] Kranz, O., Collmann, M., Hofmann, D.: KOWIND-Teilvorhaben: Material- und Bauteilprüfungen unter Offshore-Bedingungen. FKZ: 03X3561H, 2016.

In-Situ-Determination of the protection performance of coatings

Fraunhofer IFAM

- The implementation of interdigital electro-chemical sensors into the coating has been withdrawn as no solution was found to ensure the environmental durability of the sensors for longer time periods.
- A different cell design was chosen, a so called onset cell. It can be applied on demand manually and allows measurements of electrochemical impedance spectra to assess the coating protection performance.
- Electrochemical impedance spectroscopy (EIS) is a suitable method to investigate protective coatings concerning their protection properties. It is a non destructive method and allows therefore a "snap-shot" to protection related parameters of the coating.
- For EIS, a nondestructive sinusoidal potential sweep signal in the frequency range from 100 kHz to 100 Hz is applied. As response, a current signal is obtained. The complex resistance (that means the impedance), is calculated from both signals.
- The complex impedance consist of resistive and capacitive aspects which can be related to coating properties like ion conductivity, water uptake, defect evolution etc.
- In our investigations it could be shown that coating degradation like blistering could be detected much earlier than visually. Also invisible defects which may lead to beginning corrosion on the structure could be determined.

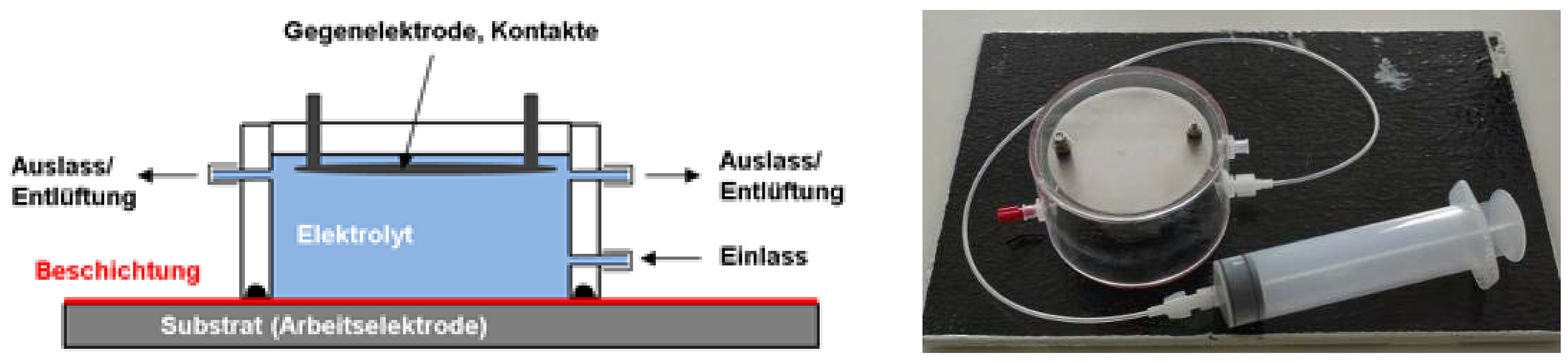

Fig. 04: Design of onset cell (suringe used to fill with electrolyte)

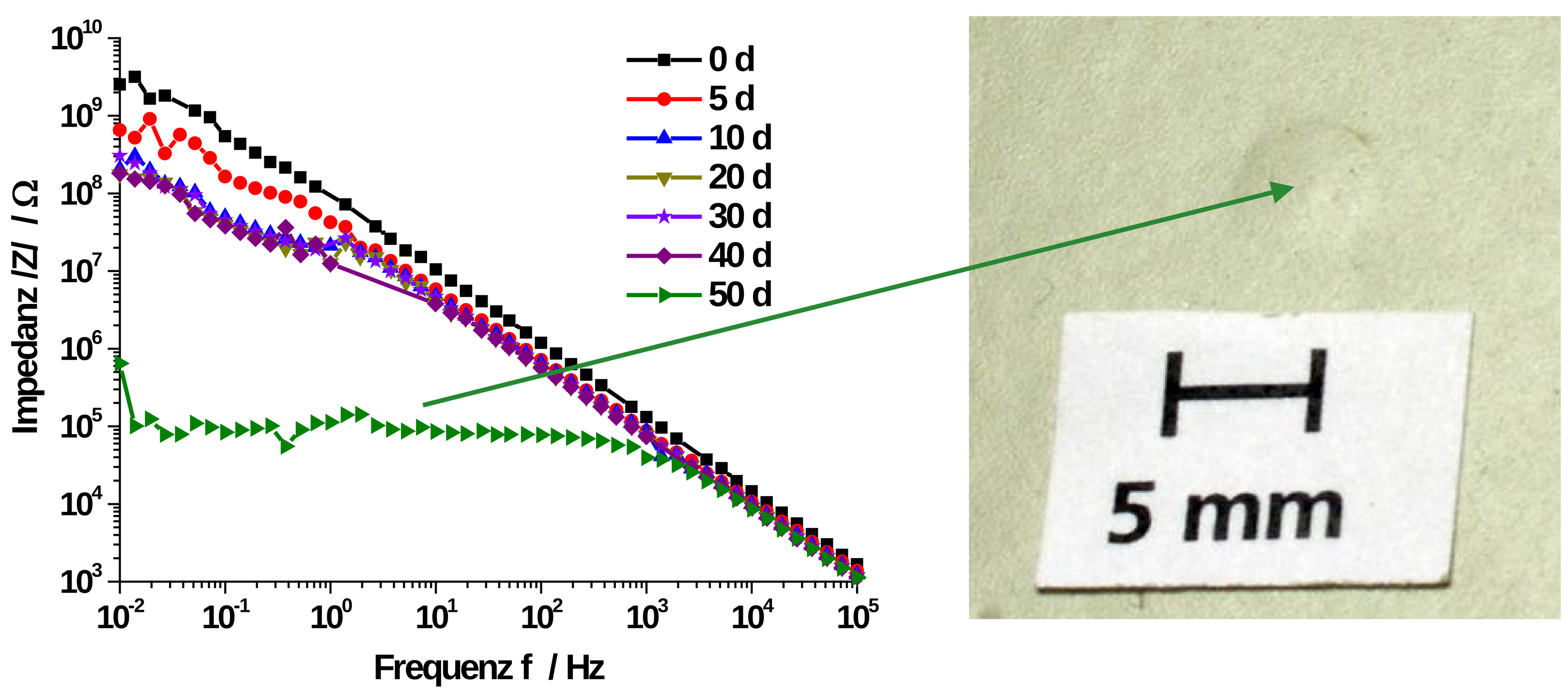

Fig. 05: Modulus of impedance and development of a bilster in a coating on steel, 3% NaCl

Conclusions

- embedded electrochemical sensors didn't show a necessary durability
- onset cell are more suitable to apply impedance spectroscopy
- invisible defects and coating degradation can be detected on demand

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