Vision of an Advanced Receiver Control System (ARC©)

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Advanced Receiver Control System (ARC©)

The receiver is the heart of the solar system. It converts the highly concentrated solar radiation into high temperature heat. This component is exposed to a complex load situation (flux distribution, transients by clouds, start up / shut down). This causes high thermal local and time depending gradients, leading to high and alternating stresses limiting the life time of the receiver.

The idea of **ARC©** is to assist the operation by finding a compromise between maximal thermal output and life time of the receiver by:

- Simulating the temperature distribution of the receiver using a numerical model of the receiver ("digital twin") using the actual load situation ("real-time boundaries").
- Assist the receiver operation by automated predictive control logic.
- Calculating stresses, analyzing load history and estimating the remaining lifetime.

Furthermore **ARC©** protects the receiver and heat transfer media from overheating and other critical situations and assists the condition monitoring for better planning of maintenance slots.

By learning from experience **ARC©** improves its algorithm continuously using artificial intelligence.

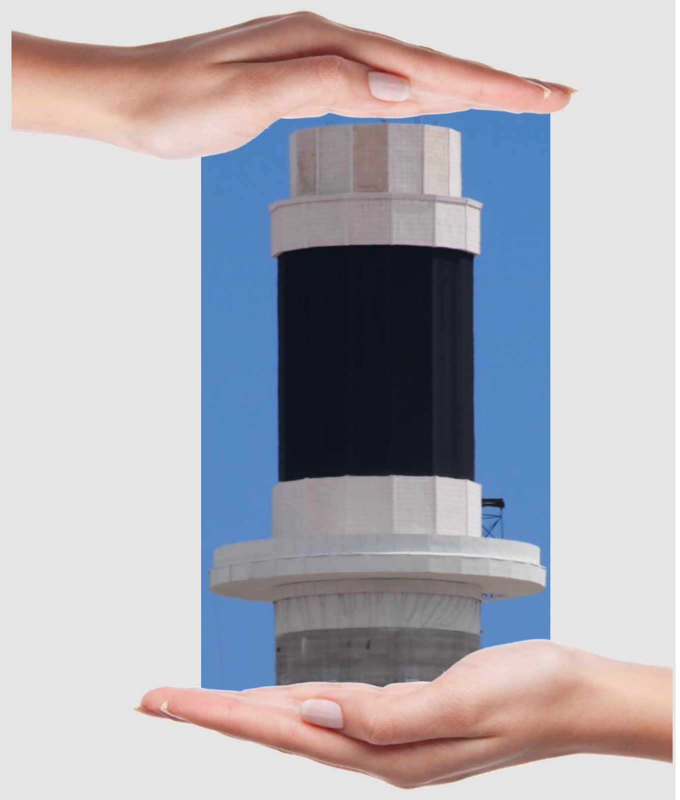

Fig. 1: Protecting the receiver

Digital twin

The receiver is represented by a numerical model considering all relevant components as built in reality. The so called "digital twin" of the receiver can be used to simulate temperatures and stresses based on measured and simulated "real-time boundaries." The model resolution is automatically adapted to the use case and the needed response time:

- Low resolution for fast (real-time) results → Assistance of the operation of the receiver
- High resolution for accurate simulation → Life time monitoring and optimization of the operation procedures

The boundaries like mass flow of the heat transfer media, the solar flux distribution and wind situation can be included by real-time measurements and simulations. The simulations can be stationary and transient and therefore consider time dependent effects.

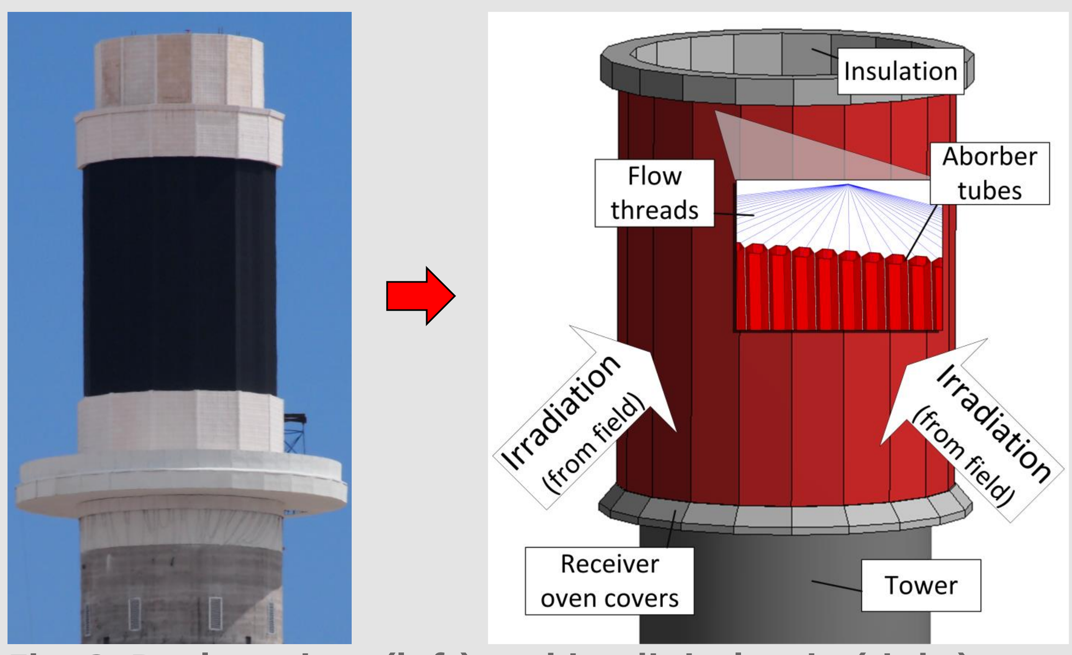

Fig. 2: Real receiver (left) and its digital twin (right)

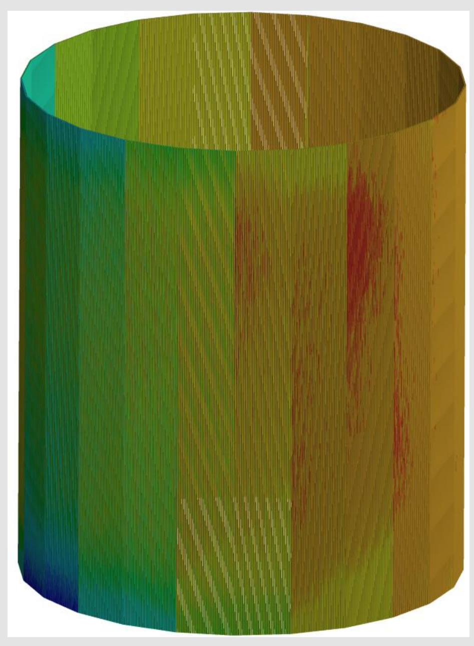

Fig. 3: Thermal model

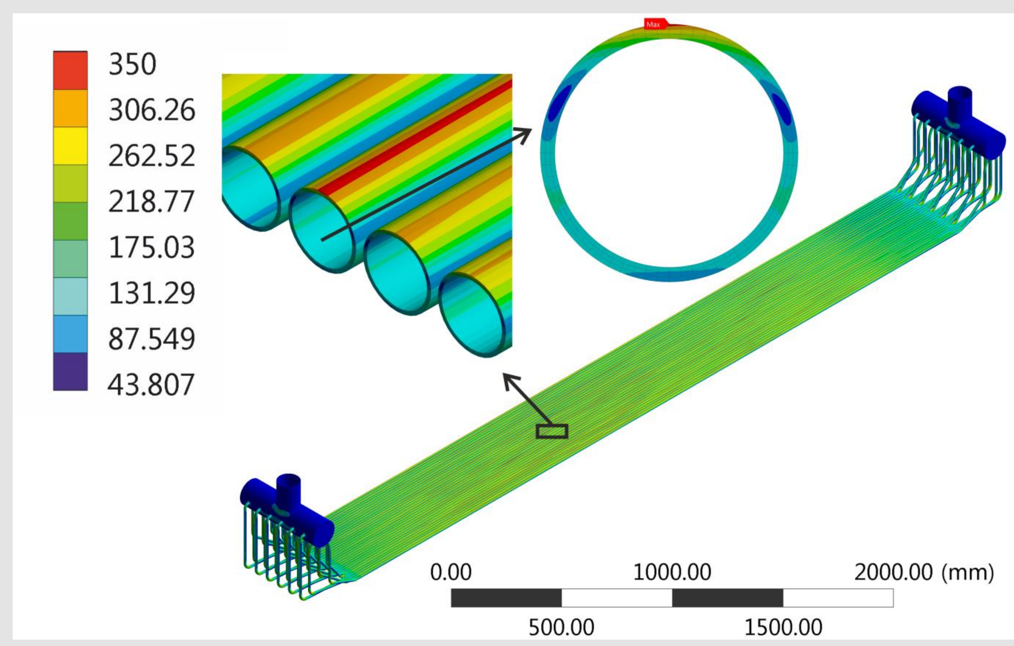

Fig. 4: Stress simulation (Mises equivalent [MPa])

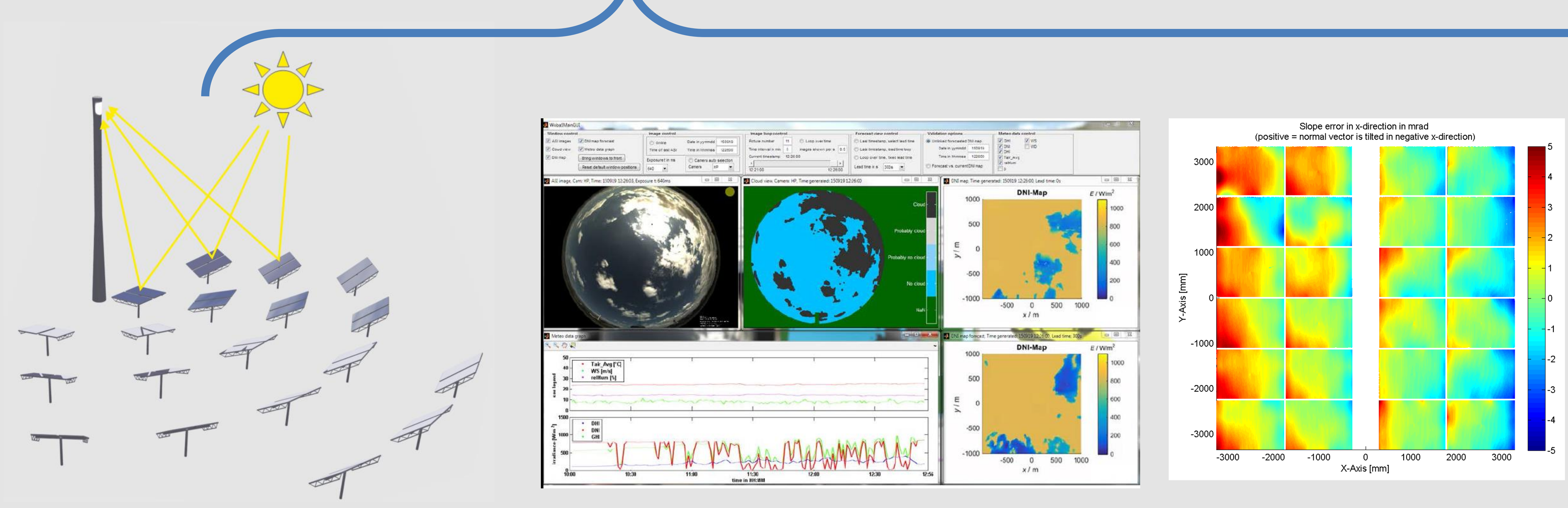

Fig. 5: Heat flux measurement and simulation including partly shading of the solar field and actual heliostat geometry.

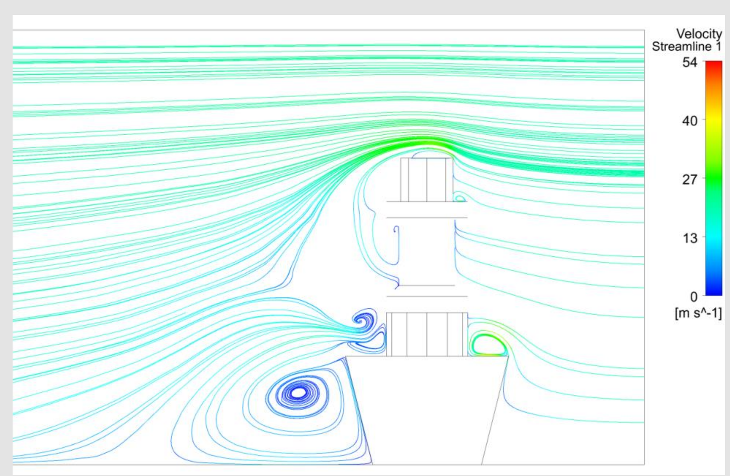

Fig. 5: Convective losses depending on wind situation

Real-time boundaries

The model is fed with real situation boundaries in real time by a combination of simulation and measurements. The heat flux distribution on the receiver can be analyzed by raytracing or measured directly on the receiver. Thereby, the heat flux is considered locally resolved on the receiver components. The accuracy of the simulations can be enhanced if the raytracer uses measurement data of the heliostat field (surface quality, reflectance).

Clouds lead to a more inhomogeneous and time depending flux distribution on the receiver and therefore the cloud situation should be taken into account. The forecasting of the flux situation is important for the predictive control. Together with the mass flow the aim points of the heliostat field are controlled to operate the receiver safe and in optimal operation strategy.

Acknowledgement

This work was partly supported by the Federal Ministry for Economic Affairs and Energy (BMWi) based on a decision of the German Bundestag. Funding codes: 0325733A / 0325655

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