https://docs.google.com/presentation/d/e/2PACX-1vRZFMhPgL39MSDGlCT3u8jIlsoTXhbKxhkkegskhkekZ016cfmfCkjy57bwHfltyg/pub?start=false&loop=false&delayms=3000&slide=id.p1 LINK

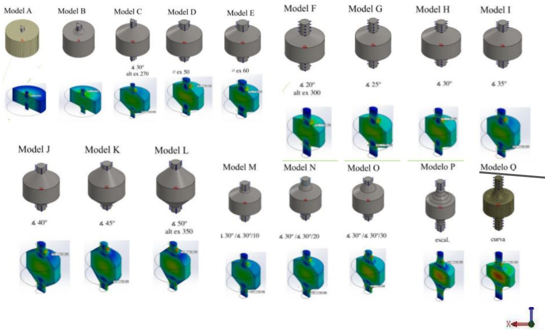
Investigation of Geometries and Stability for Increasing the Energy Density in Electromechanical Battery Flywheels: New Geometry Proposal

Carlos Frajuca

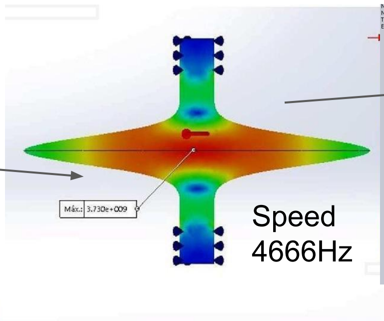
The energy density stored in a flywheel rotor is estimated by

$$\frac{E}{m} = \frac{\sigma_{max}}{2\rho}$$

Many previous tests

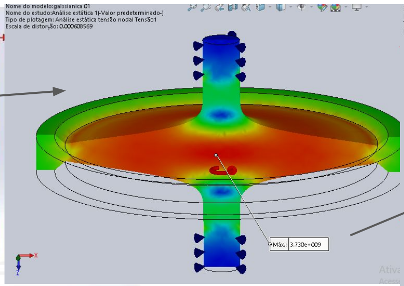


Gaussian shape

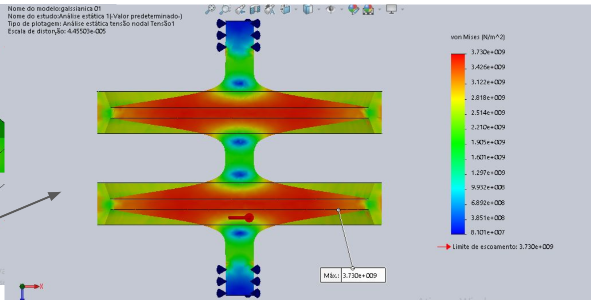


Speed 4666Hz

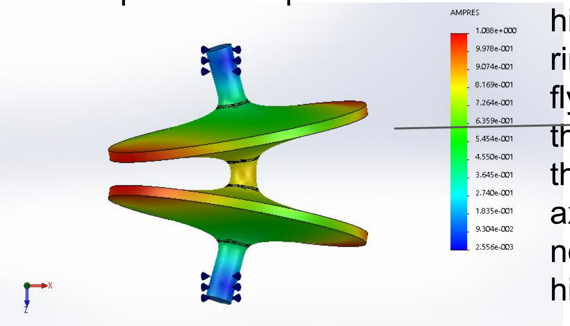
Adding side mass: E/m = 1.59 MJ/kg



Adding energy, E/M = 1.52 MJ/kg

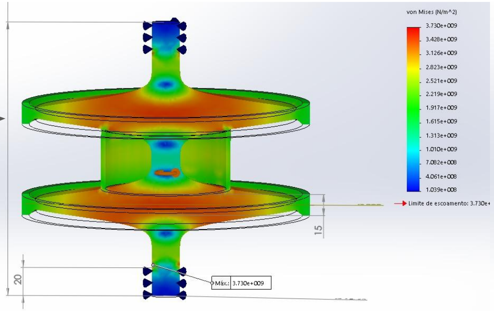


Instability at 1 kHZ, lower than operational speed

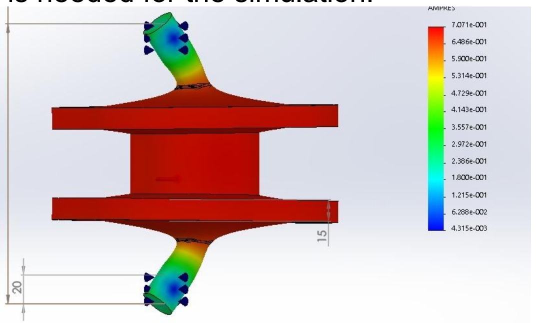


To make the instability speed higher, a 3 mm wall ring is add to the flywheel geometry, this ring increases the rigidity of the axle and make the normal frequencies higher.

New Geometry:E/M=1.45MJ/kg



Instability at 2.5 kHz but can be increased making the axle shorter. Its is needed for the simulation.



JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

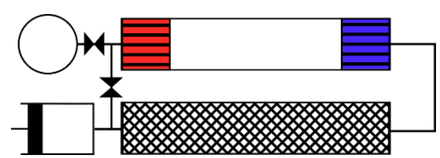
cryo.TransMIT

Characterization of the cooling power and energy efficiency on a two stage 4 K pulse tube cooler operated with solenoid valves

- Where are **Pulse Tube Cryocoolers** needed:
  - **Power generation/transmission – HTS**
  - Fundamental research – IR astronomy
  - Medical – MRI
  - Quantum computing
  - Ground exploration – Ore detection

- Advantage over other methods of cooling:
  - Energy efficient
  - **Closed cycle – no loss of fossil He**
  - Robust
  - Compact

GE 1.7 MW HTS gen.



Xaver Herrmann

791st WE-Heraeus-Seminar, 18 to 22 June

IAP

[1] https://www.ge.com/news/press-releases/ge-successfully-trials-breakthrough-high-temperature-superconducting-technology-next (accessed: 01.06.2023)

Characterization of the cooling power and energy efficiency on a two stage 4 K pulse tube cooler operated with solenoid valves

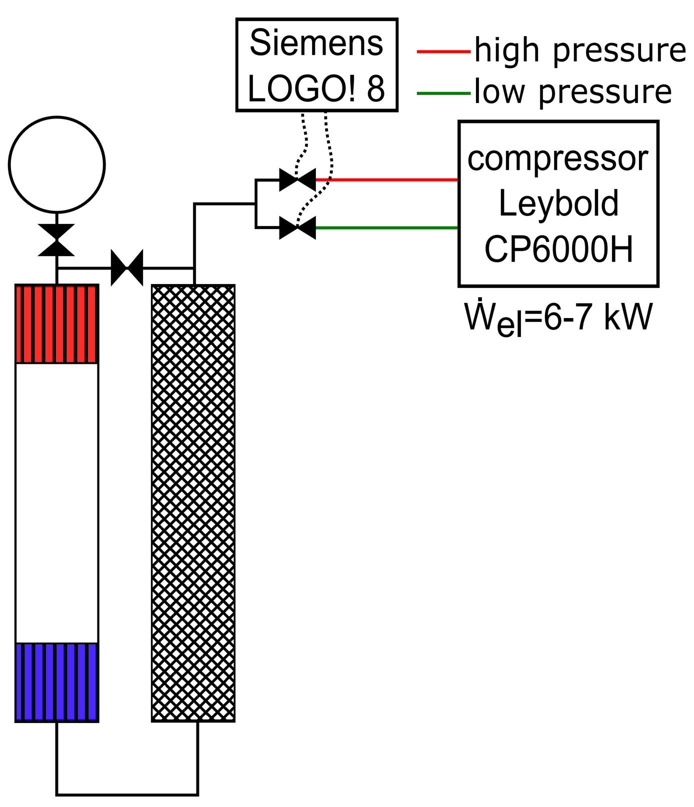
Xaver Herrmann[1,2], Jack-André Schmidt[1,2], Bernd Schmidt[1,2], Jens Falter[1], and André Schirmeisen[1,2]

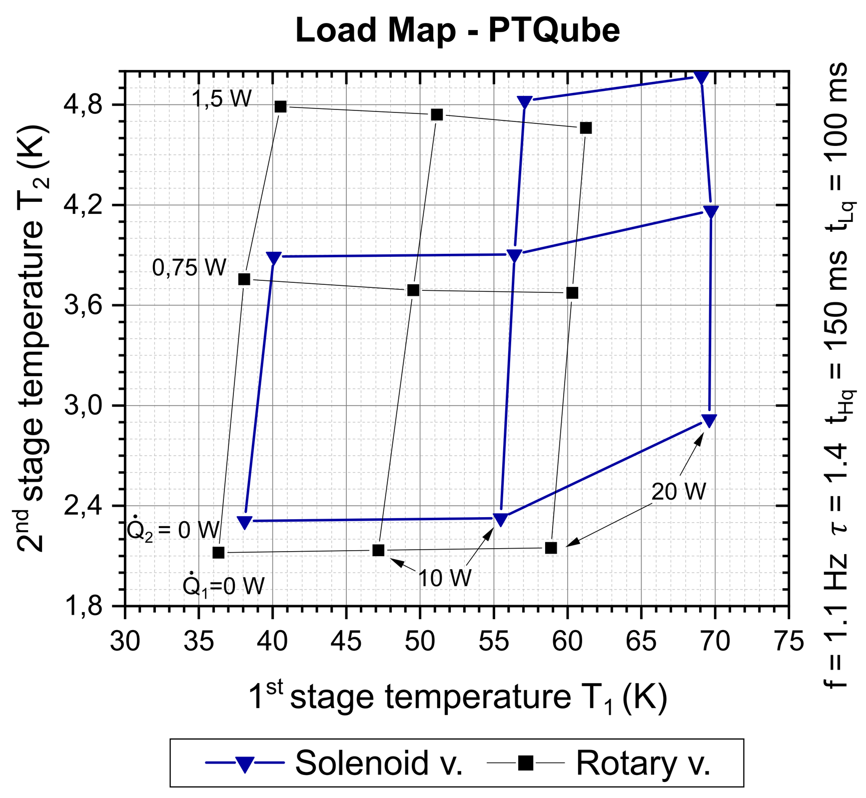
[1]TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany
[2]Institute of Applied Physics (IAP), Justus-Liebig-University Giessen, Germany

Pulse tube cryocooler (PTC)

- Since discovery of supercondictivity, cooling power at cryogenic temperatures is needed[1]
- Pulse Tube Cryocoolers (PTC)[2,3] combine high cooling power with a regenerative closed system
- PTCs are typically driven by rotary valves which have intrinsic exergy losses due to gas bypass[4]
- Solenoid valves can reduce gas bypass and offer easier adjustment of timimg parameters

Cryocooler, valves and compressor

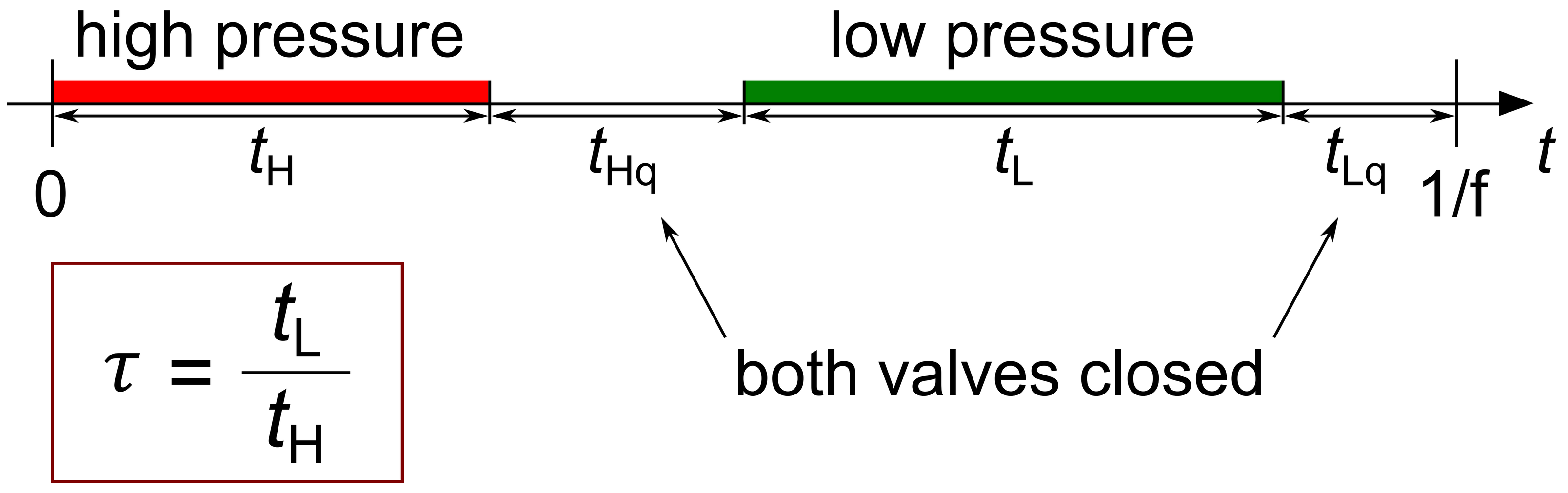




COP = $1{,}5 \cdot 10^{-4}$ @ 4.2 K

- Compressor: Leybold CP6000H provides high and low pressure reservoirs: $\Delta p \approx 15$ bar
- Solenoid valves connect PTC with high or low pressure reservoir with **variable** valve timing
- Resulting pressure wave inside PTC causes heat transfer from lower to upper part
- Cooling power depending on valve timing[5]

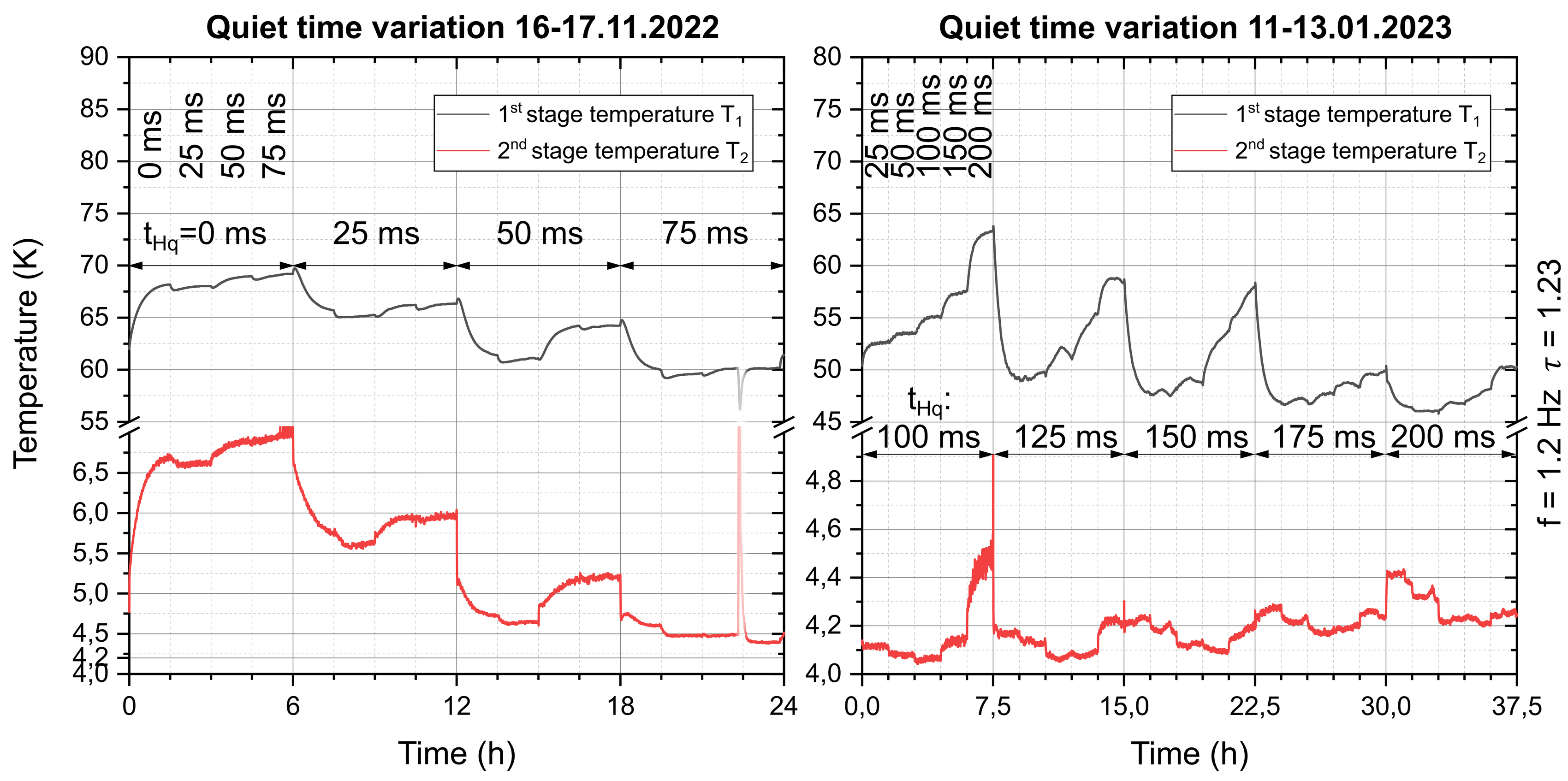
Valve parameters



$$\tau = \frac{t_L}{t_H}$$

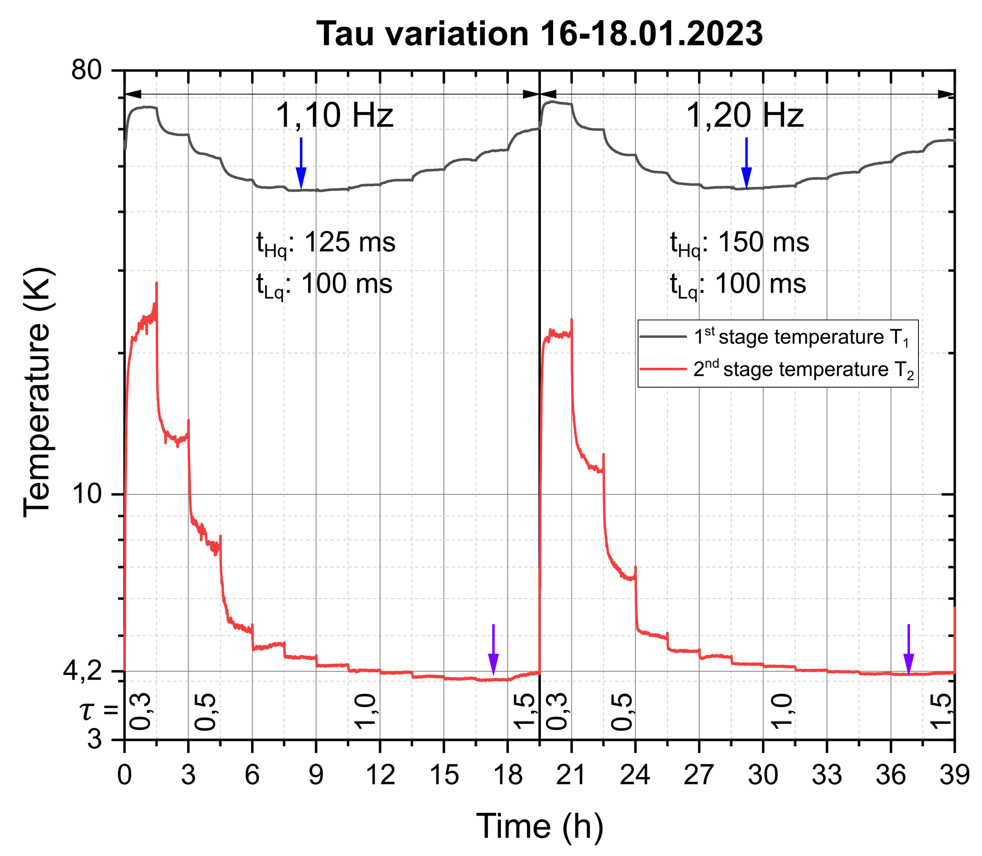
- [4] states τ = 1.23 as optimal setting for maximum performance

Quiet time dependence



- Longer high pressure quiet times increase performance of first stage
- Best second stage performance for similar low and high pressure quiet times

τ-dependence of cooling power



- τ = 1.23 is a good compromise between first and second stage
- Two different settings for optimal performance of frist and second stage

Conclusion

- Solenoid valves can be used to drive a PTC with similar performance to rotary valve
- Valve timing parameters like frequency, τ and quiet times are easily adjustable
- Different τ for optimal performance of first or second stage
- Quiet times have high influence on first and second stage performance

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TransMIT Gesellschaft für Technologietransfer mbH
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Heinrich-Buff-Ring 16, 35392 Giessen

[1] H.K. Onnes, Investigations into the properties of substances at low temperatures, which have led, amongst other things, to the preparation of liquid helium, Nobel lectures, Vol. 4, (1913), 306-336
[2] G. Thummes, et al., Small scale ^{4}He liquefaction using a two-stage 4 K pulse tube cooler, Cryogenics, Vol. 38.3, (1998), 337-342
[3] R. Radebaugh, Development of the pulse tube refrigerator as an efficient and reliable cryocooler, Proceedings of Institute of Refrigeration, Vol. 96, (1999), 11-31.
[4] D. Liu, M. Dietrich, G. Thummes, Z. Gan, Numerical simulation of a GM-type pulse tube cryocooler system: Part II. Rotary valve and cold head, Cryogenics, Vol. 81, (2017), 100-106.
[5] L.M. Qiu, G. Thummes, Valve timing effect on the cooling performance of a 4 K pulse tube cooler, Cryogenics, Vol. 42, (2002), 327-333.

A Series of Lectures for Pupils on the Possible Yield of Renewable Energies in Germany

Michael Kahnt

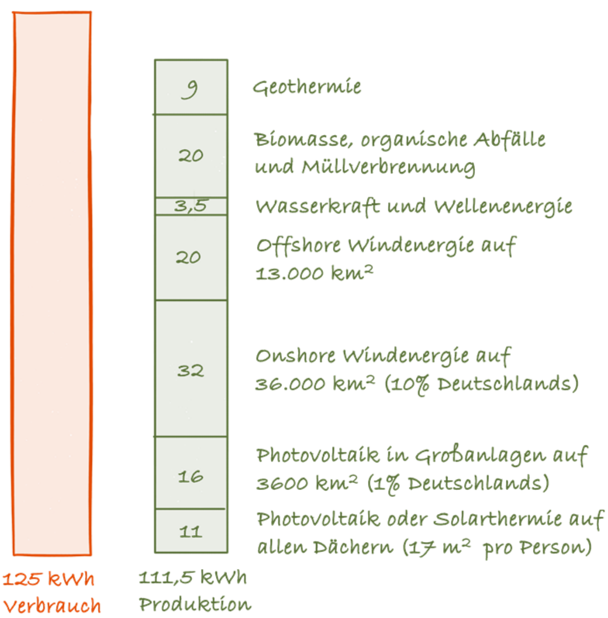
Background

Although there is already a wide range of material for teaching on the subject of climate change [e.g. 1, 2], according to the curricula of many federal states, the treatment in physics lessons is not yet an important topic. If you also look at the teaching materials on this topic, it becomes clear that the focus is strongly on the causes and mechanisms of climate change (e.g. the greenhouse effect), but hardly on potential solutions with their technical requirements and challenges.

For this reason, a seminar for student teachers was held at the University of Osnabrueck in the 2022/23 winter semester, in which the students dealt with renewable energies. The basis for this was the literature [3], but of course other specialist literature such as [4].

Contents

In the main literature, the primary energy requirement (for the year 2017) is given and converted into the unit "kWh per person and day". This makes the very large amounts clear.

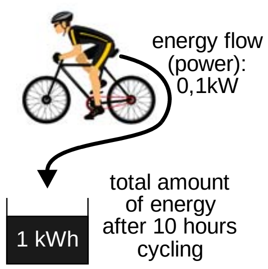


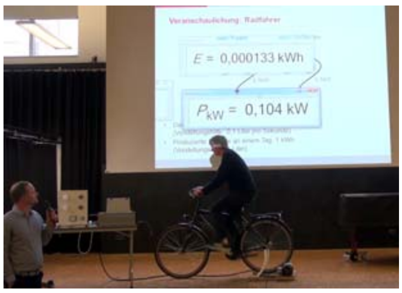
Then the regenerative energies of photovoltaics, solar thermal energy, wind, water, biomass and geothermal energy are dealt with. Their possible yield is estimated under very optimistic conditions. Primary energy requirements and the yields from regenerative energies are shown as columns..

Lecture series at school

After the end of the seminar, the idea came up to pass on the findings. Therefore, a series of lectures (three evening dates was planned and carried out at the Graf-Stauffenberg-Gymnasium in Osnabrueck. In addition to the pupils, parents, teachers and the interested public were also invited.

Of course, the content had to be adapted to the audience. Complex calculations were therefore omitted. Small experiments (e.g. on wind energy) were also carried out. Above all, the unit "1kWh" was clearly illustrated with the help of a bicycle generator.





Feedback and further perspective

Each evening of lectures lasted about 90 minutes. Participation was disappointingly low (about 20 people). However, those present were enthusiastic and very grateful for the information. It was emphasized that it was particularly important to get an idea of the quantitative dimensions. The lectures are now to be offered again during class times for schoolchildren.

Quellen:
[1] Klimawandel – im Spannungsfeld zwischen Wissenschaft und Gesellschaft. Naturwissenschaft im Unterricht Physik 32 (2021), Heft 183,184.
[2] Klimawandel verstehen und handeln. Internet: https://klimawandel-schule.de/de
[3] Holler, C., Gaukel, J.: Erneuerbre Energien ohne heiße Luft. München: Oekom-Verlag, 2018.
[4] Quaschning, V.: Regenerative Energiesysteme. Technolige – Berechnung – Klimaschutz. München: Hanser-Verlag, 2022.

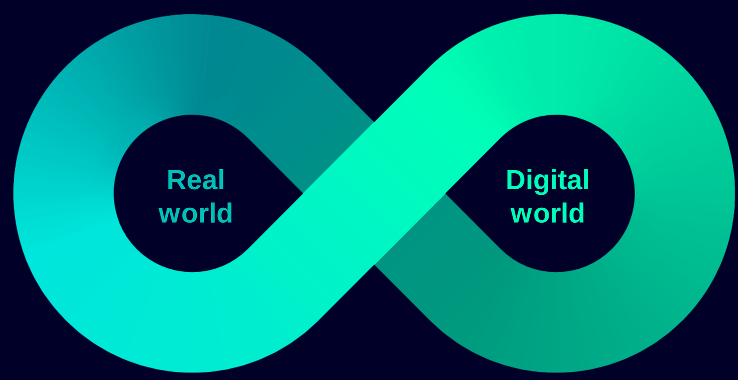
SIEMENS

Environmental benign process intensification: Additive Manufacturing for process applications

Christoph Kiener, Tobias Kamps, Yves Küsters, Uliana Söllner, Robert Otto, Manuel Biedermann, Stefan Boschert, Thomas Braun, Alexander Nicolai, Diego Montalvo, Alex Jastram, Angelo Rudolphi

Siemens AG, Technology, Munich / Berlin, Germany

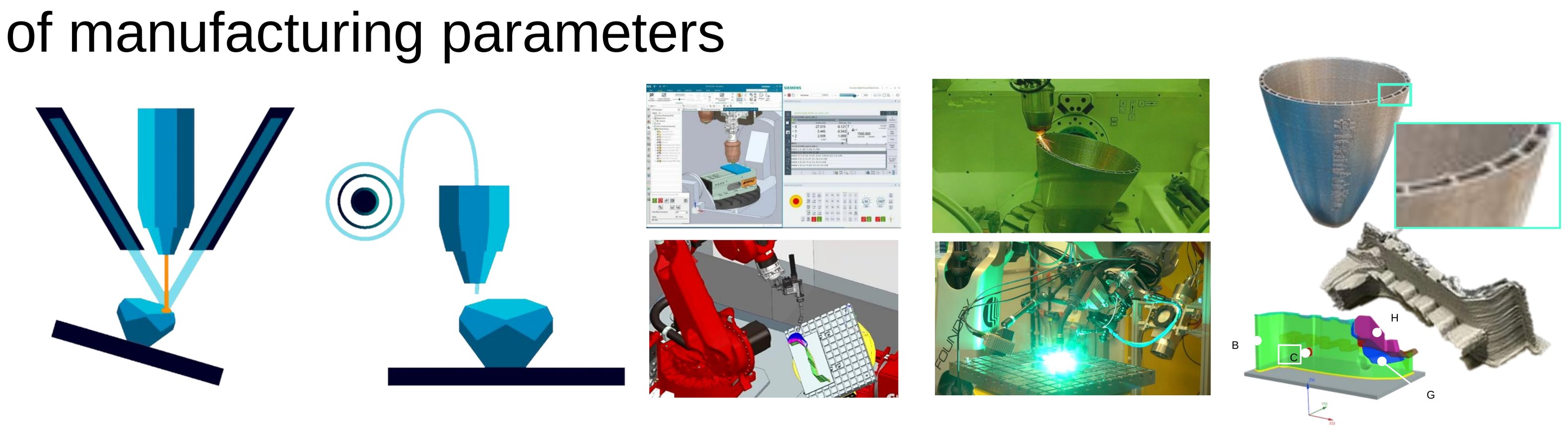
Additive Manufacturing (AM; „3D printing“) is the concept of 3D space-resolved, machine-based, tool-free digitally controlled material solidification. Several techniques (welding, sintering, sheet lamination, gluing, de-bindering/sintering) and materials (metals, polymers, ceramics, composites) are commercially available so far, but development continues.



Geometries realized by AM have a high degree of freedom; for metals, a range from 10 µm to 1 meter is accessible. No molds or tools are required, so it is attractive for individualization and small series parts. As a fully digital method, 3D designs can be optimized through multi-physics simulation prior to realization in multiple alloys.

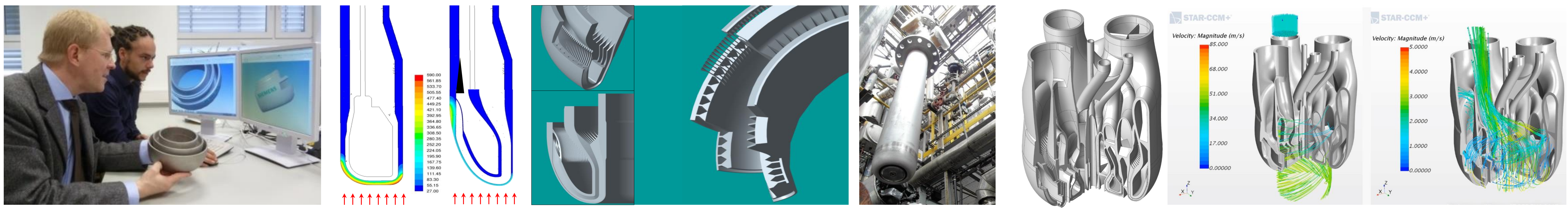
Manufacturing technologies: material placement with full control of manufacturing parameters

Planar: laser beam metal powder bed fusion (PBF-LB/M)



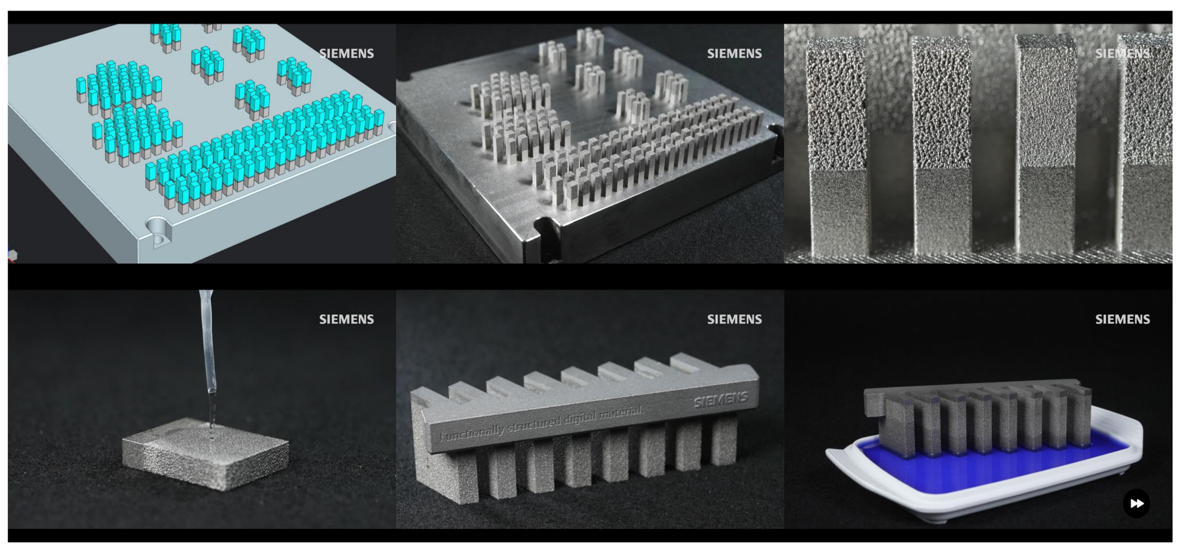
Multi-axis: directed energy deposition (DED); wire arc AM (WAAM)

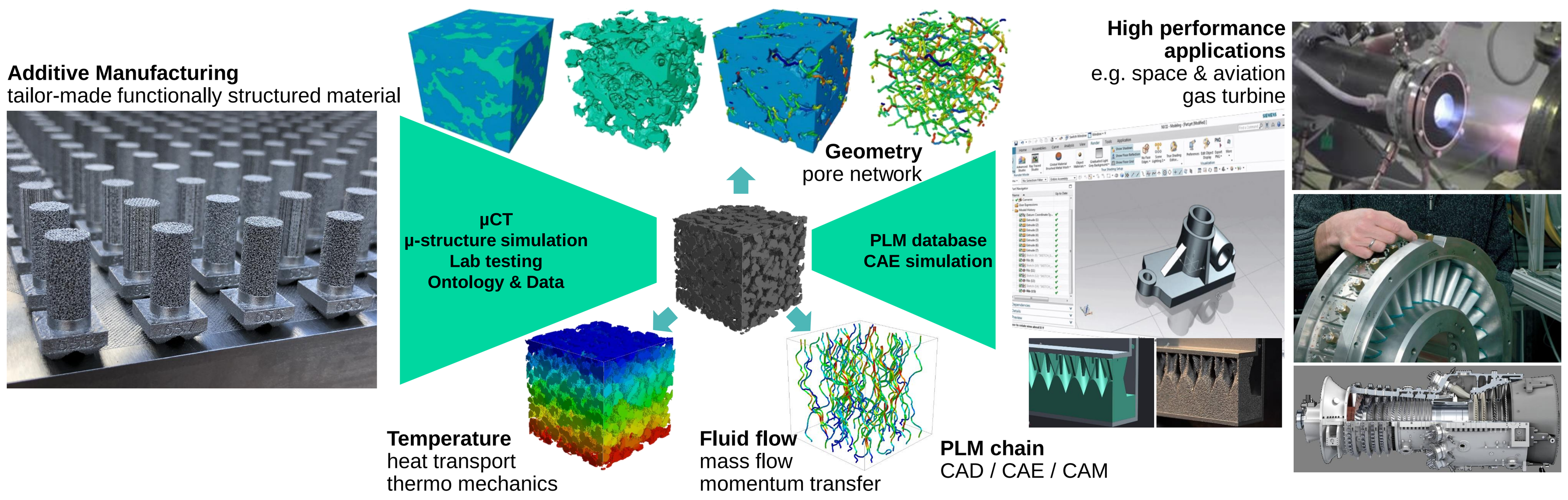
Hierarchic functionality: Interaction in centimeter range…



Redesign of a Burner Tip with Multiple Integrated Flow Distributors. Biedermann M., Kamps T., Kiener C., Fraunhofer Direct Digital Manufacturing Conference, DDMC 2018: Conference Proceedings, page 389, Fraunhofer Verlag 2018. https://tinyurl.com/6f4nf4d7

…combined with 10 - 1000 µm range structures

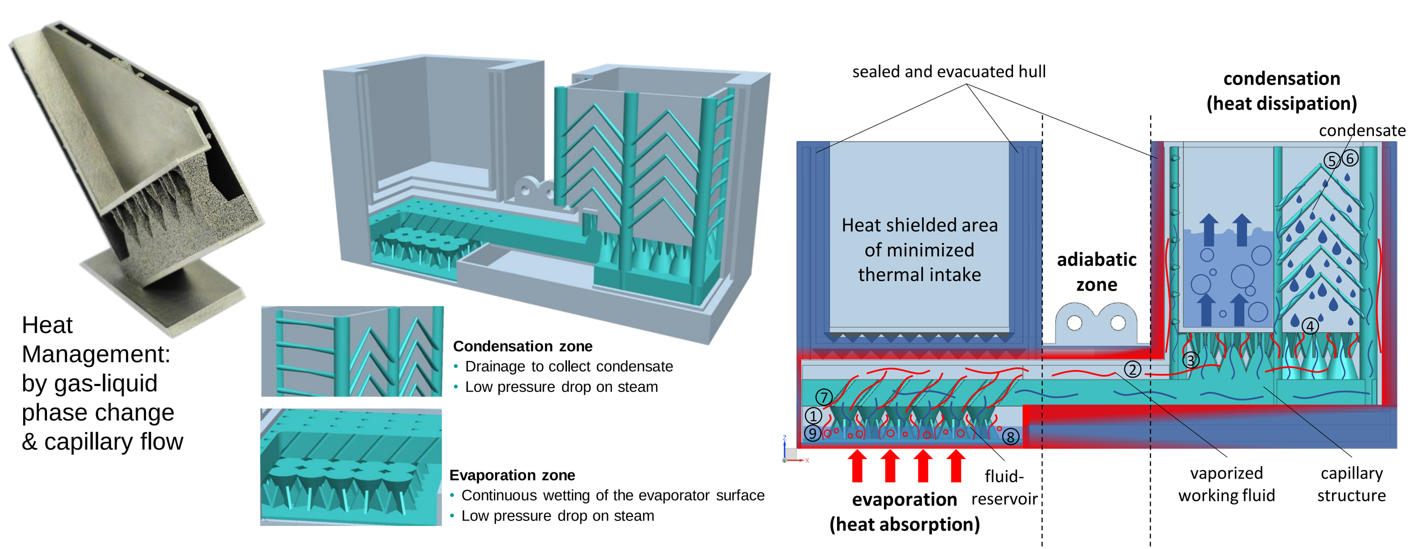




Additive manufacturing of open porous functional structures: roadmap from manufacturing to the application. Otto R., Kiener C., Küsters Y., Sorby K., Procedia CIRP 112 (2022) 334 – 339 https://doi.org/10.1016/j.procir.2022.09.102

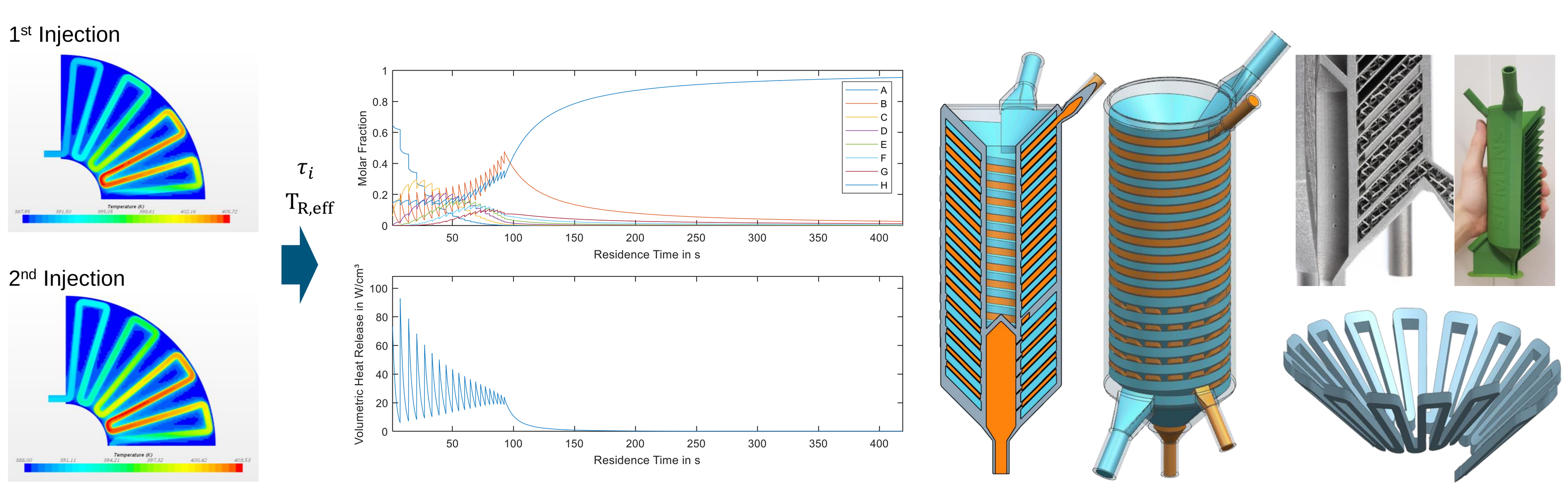
Synchrotron µ-CT-based morphological characterization of additively manufactured open porous structures. Otto R., Sørby K., Hesse B., Gerber J., Bortel E., Kiener C.,. Additive Manufacturing 55 (2022) 102874 https://doi.org/10.1016/j.addma.2022.102874

Heat transfer applications



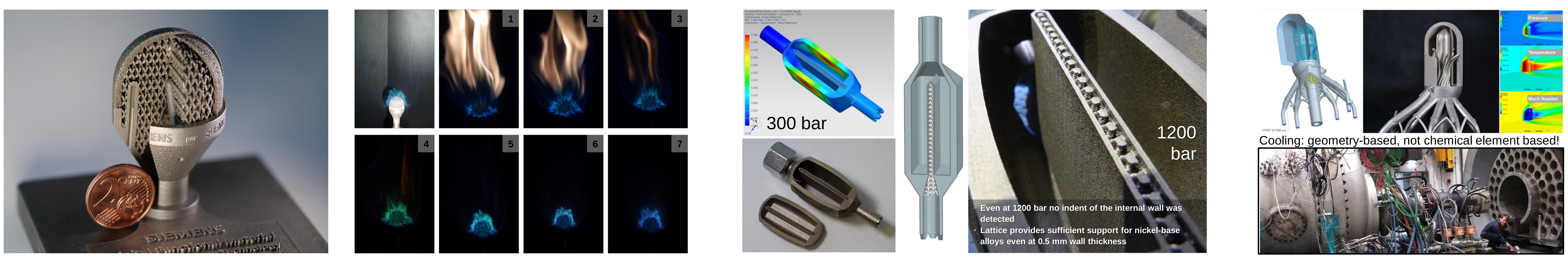
Additive Fertigung multi-funktionaler Bauteile. Braun T., Kiener C., wt Werkstattstechnik online, 110 (7/8), 526-531 (2020).

Liquid-liquid reaction technology



Simulation-Driven Design of an Additively Manufactured Reactor for Exothermic Liquid-Liquid Reactions. Kiener C., Jastram A., Schaack S. Chem. Ing. Tech.2022,94, No. 7, 948-95 https://onlinelibrary.wiley.com/doi/10.1002/cite.202200050

Reaction technology making use of AM-made structures



Hochdruck-geeignete AM-Konstruktionselemente mit hierarchisch-funktionalen Metallstrukturen. Kiener C., Boschert S., Küsters Y. , Nicolai A. , Otto R.,. Chem. Ing. Tech.2022,94, No. 7, 1040-1045 https://onlinelibrary.wiley.com/doi/10.1002/cite.202200050

Technological constraints concerning the 1.5K limit – Probability Aspects

M.Pabst; Özel Alman Lisesi, Şahkulu, Şah Kulu Bostan Sk. No. 10, 34420 Beyoğlu/İstanbul, Turkey

Who: Graduation high school class 2021: Friedrich-Dessauer-Gymnasium, Frankfurt/Main

Question: Is there any evidence that the 1.5K-limit will be kept by technical steps?

Starting Point: "FFF-study" of Wuppertal-Institute (2020).

IPCC budget-approach → necessity of climate-neutrality already in 2035.

Conclusion: "**Keeping the limit is extremely challenging but basically possible**."

Method: Examination of 8 steps and requirements from FFF-study [1].

Comparing them to real situations and projects.

Poster session: Only one aspect presented (Import of higher amount of green energy)

Result: Each of the 8 steps seems to be quite unlikely.

Nevertheless, suppose each aspect with a reasonable probability of 50%.

Estimation with path-rules leads to **overall probability** of **0,2%.**

Conclusion: **There is no evidence that the 1.5K-limit can be hold by technical steps.**

Following research questions

- How probability estimations can be included in energy planning, even if probability cannot exactly be calculated?
- Role of the scientist: How progress in technology should be presented to avoid overoptimistic estimations of decision makers?

---

[1] List of evaluated steps and requirements; all until 2035.

1. Expansion of renewable energy plants.
2. Import of renewable energy.
3. Import only from countries that are then climate neutral.
4. Storage of electricity.
5. Capacity for H_2 and PtX production in Germany.
6. Political and economical implications of the change of industry towards CO_2-neutrality.
7. Change in house heating systems and house insulation.
8. Extension of railway system.

Technological constraints concerning the 1.5K limit – Probability Aspects

M. Pabst

Özel Alman Lisesi, Şahkulu, Şah Kulu Bostan Sk. No. 10, 34420 Beyoğlu/İstanbul, Turkey

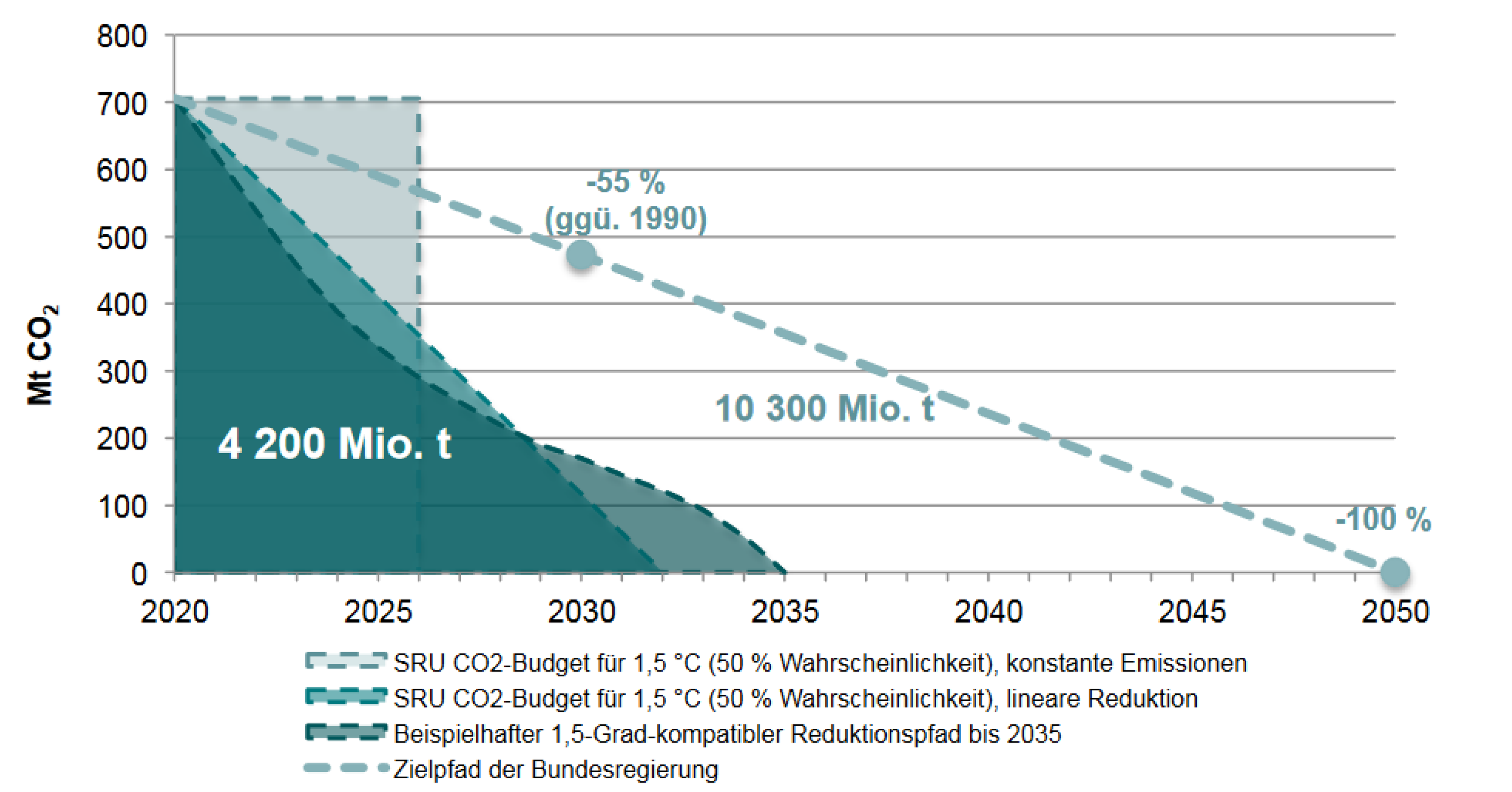
Who: Graduation class of German High school in 2021: Friedrich-Dessauer-Gymnasium, Frankfurt/Main

Research question: Can the technical facilities and their realization reliably keep the 1.5K limit?

Thesis: No. There is NO evidence.

Starting Point: FFF-Study of Wuppertal-Institute (G. Kobiela et al., 2020)

- Budget approach based on IPCC data; implies: 1.5K-limit can be hold with probability of 50%.
- As a consequence: Energy neutrality must be reached already in 2035 (ebd. 11)
- Discussion of resulting mandatory steps
- Conclusion:
  "Keeping the limit is extremely challenging but basically possible" (ebd. 10)



Our assessment:

- FFF-study discusses at least ten required actions and presumptions.
- We examined eight of them by comparison to real projects.
- Here exemplary: **Import of renewable energy to a great extend** (ebd. 46-48).

Comparison to solar plant **Ouarzazate (Morocco)** (Wikipedia 2022)

- $P_{ges:}$ 500...580MW
- Energy gain 1'350GWh/a

- Construction time: 5 years;
- Invest: 2,7Bio $
- Area $25km^2$

Comparison to energy demand in 2035 (FFF-study):

- **120** plants for 10% of German Energy demand
- **410** plants in case of "import of H2 to big extend"

Consequence: There is **no evidence** that the required amount of energy can be imported by 2035.

Total probability estimation:

Suppose: To each of the FFF-study requirements can be assigned a probability of 50%.

Calculation using path rules: The total probability for keeping the 1.5K-limit is $\mathbf{(0{,}5)^9 = 0{,}2\%}$

<u>**Conclusion**</u> **There is no evidence that the 1.5K-limit can be hold by technical steps.**
As every single point has a valuable probability, this result is surprising and not known, especially for political decision makers.

<u>**Following research questions**</u>

- How probability estimations can be included in energy planning, even if probability cannot exactly be calculated?
- Role of the scientist: How progress in technology should be presented in order to avoid overoptimistic estimations of decision makers?